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# JACKPILE-PAGUATE URANIUM MINE RECORD OF DECISION COMPLIANCE ASSESSMENT

**September 2007**

***Prepared for:***
**Pueblo of Laguna**

***Prepared by:***
**OA Systems Corporation**

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# JACKPILE - PAGUATE

# Uranium Mine Reclamation Project

## RECORD OF DECISION

DECEMBER 1986

**US DEPARTMENT OF THE INTERIOR**

**BUREAU OF LAND MANAGEMENT**
**ALBUQUERQUE DISTRICT OFFICE**

**BUREAU OF INDIAN AFFAIRS**
**ALBUQUERQUE AREA OFFICE**

The following measures are approved as the minimum level of reclamation required under the scope of the Record of Decision:

1. Pit Bottoms

A. Backfill Levels

Pts will remain as closed basins. Pit bottoms will be backfilled to at least 10 feet above the Dames and Moore (1983) projected ground water recovery levels as indicated below. A schematic diagram is shown in the FEIS, Appendix A (Figure A-1, DOI Proposal).

| Proposed Minimum Pit Backfill Levels | |
|---|---|
| Jackpile | 5939' |
| North Paguate | 5958' |
| South Paguate | 5995' |
| South Paguate (SP-20) | 6060' |

A groundwater recovery level monitoring program will be implemented. Additional backfill will be added as necessary to control ponded water. The duration of the monitoring program will be a minimum of 10 years.

B. Backfill Materials

Backfill materials will consist of protore, waste dumps H and J, and excess material obtained from waste dump resloping and stream channel clearing. These materials will be covered with 3 feet of overburden and 2 feet of topsoil (i.e., Tres Hermanos Sandstone or alluvial material).

C. Stabilization

All backfill slopes will be reduced to no greater than 3:1 (horizontal to vertical). Surface water control berms will be constructed within pit bottoms to reduce erosion and retain soil moisture for plant growth. Surface runoff will also be directed to small retention basins in the pit bottoms. All areas in the pits will then undergo surface shaping, topsoil application and seeding as outlined under "Revegetation Methods" below.

D. Post-Reclamation Access

Human and animal access to pit bottoms will be prevented. Livestock grazing will be prevented with the use of sheep-proof fencing due to the uncertainties of predicting radionuclide and heavy metal uptake into plants (forage).

2. Pit Highwalls

A. Jackpile Pit Highwall

The top 15' of highwall will be cut to a 45 degree slope. All soil and unconsolidated material at the top of the highwall will be sloped 3:1. The highwall will be scaled to remove loose debris. A schematic diagram is shown in the FEIS, Appendix A (Figure A-7).

B. North Paguate Pit Highwall

The top 15' of highwall will be cut to a 45 degree slope. All soil and unconsolidated material at the top of the highwall will be sloped 3:1. The highwall will be scaled to remove loose debris. A schematic diagram is shown in the FEIS. Appendix A (Figure A-7). Additionally, the highwall will be fenced with 6-foot chain link.

C. South Paguate Pit Highwall

The top 15' of highwall will be cut to a 45 degree slope. All soil and unconsolidated material at the top of the highwall will be sloped 3:1. The highwall will be scaled to remove loose debris. A schematic diagram is shown in the FEIS, Appendix A (Figure A-7). Additionally, the highwall will be fenced with 6-foot chain link.

3. Waste Dumps

Waste dumps H and J will be relocated to Jackpile pit as backfill. Most dump slopes will be reduced to 3:1 or less and the dump slopes will be contour furrowed; exceptions are noted in

Table 1-4 of the FEIS. Dumps which have Jackpile Sandstone on their outer surface and any Jackpile Sandstone exposed during resloping will be covered with 3 feet of overburden and 16 inches of topsoil. Dumps that do not contain Jackpile Sandstone on their outer surfaces will be covered with 18 inches of topsoil. Berms will be installed on all dump crests to control erosion. All dump tops will slope slightly away from their outer slopes. Dump slopes will be contoured so their toes are convex to prevent formation of major gullies on slopes. Additional surface treatment is outlined under "Revegetative Methods" below. Detailed modifications and treatments are presented in Table 1-4 of the FEIS. A schematic diagram is shown in the FEIS, Appendix A (Figure A-9).

4. Protore Stockpiles

All protore will be used as backfill material in pit areas. Backfill will be covered with 3 feet of overburden and 2 feet of Tres Hermanos Sandstone or alluvial material.

5. Site Stability and Drainage

A. Stream Stability

All contaminated soils and fill material within 100 feet of the Rio Paguate west of its confluence with the Rio Moquino will be excavated and relocated to the open pits. For the Rio Moquino, waste dumps S, T., U., N and N2 will be pulled back 50 feet from the centerline of the stream channel. The toes of these dumps will be armored with riprap. A concrete drop structure will be constructed across the Rio Moquino approximately 400 feet above the confluence with the Rio Paguate.

B. Arroyo Headcutting

Arroyos south of waste dumps I, Y and Y2, and the arroyo west of waste dumps FD-1 and FD-3 will be armored as shown in the FEIS, Appendix A (Figure A-13). Other headcuts encountered during reclamation will also be stabilized by armoring.

C. Blocked Drainages

Waste dump J and protore stockpiles SP-17BC and SP-6-B will be removed to unblock ephemeral drainage on south side of minesite. Two blocked drainages north of FD-1 and F dumps will remain blocked. Remainder of minesite, excluding open pits, will drain to Rios Paguate and Moquino.

6. Surface Facilities/Structures

A. Lease No. 1 (Jackpile Lease)

All buildings on Lease No. 1 will be demolished and removed except for the Geology building, miner trainer center and buildings at Old Shop and the Open Pit offices. The land surface (except pit highwalls and natural outcrops) will be cleared of radiological material (e.g., Jackpile Sandstone) until gamma readings of twice background or less are achieved. These areas will then be graded and seeded.

B. Lease No. 4

All structures and facilities associated with P-10 Mine and New Shop, including all buildings, roads, parking lots, sewage systems, power lines and poles will be left. All operational and maintenance equipment, including tools, machinery, supplies will be removed. All permanent structures and land surfaces (except pit highwalls and natural outcrops) will be cleared of radiological material until gamma readings of twice background or less are achieved. These areas will then be graded and seeded. Nonsalvageable contaminated buildings and materials will be removed to the pits for disposal.

C. Access Routes

The four major roads within minesite will be cleared of radiological material and left after reclamation for post-mining use. These access routes include: 1) access road from P-10 and

New shop to State Highway 279; 2) main road through mine; 3) road that passes between housing area and North Oak Canyon Mesa and then proceeds to P-10; and 4) road to Jackpile Well No. 4. All other roads (except on Lease No. 4) will be removed. These areas will then be graded and seeded.

D. Water Wells

Jackpile Well No. 4, P-10 Well, New Shop Well and Old Shop Well, and 3 wells and their associated sheltering structures (near housing area) will be left. The pumps, riser pipe, wiring and water storage tanks will be removed. Wells established for future monitoring purposes will also be left. All wells will be capped to prevent dust, soil and other contaminants from entering the well casing.

E. Rail Spur

The rail spur will be left intact and cleared of radiological material until gamma readings of twice background or less are achieved. Quirk loading dock will be demolished and hauled to the pits.

7. Drill Holes

All drill holes will be plugged according to the State Engineer's requirements. A 5-foot surface concrete plug will also be placed in each hole. Any cased holes will have the casing cut off at the surface. In addition, areas around drill holes will be seeded. Any exploration roads not wanted by the Pueblo will be reclaimed.

8. Underground Modifications

A. Ventilation Holes

Vent holes will be backfilled with waste material (Dakota Sandstone and Mancos Shale) to within 6 feet of surface. Surface casing will be removed, steel support pins installed in walls of vent holes, and sealed with a 6-foot concrete plug from backfill to surface. Areas around vent holes will be contoured and seeded.

B. Adits and Declines

A concrete bulkhead will be constructed approximately 680 feet below portal of P-10 decline. The decline will be backfilled from bulkhead to ground surface with Dakota Sandstone and Macos Shale. Sufficient material will be placed over the portal to allow for compaction and settling. The ground surface above the buried portal will be sloped and then top-dressed and seeded. The Alpine mine entry will be bulkheaded and backfilled. Mine entries not previously plugged by backfilling will be covered. Additionally, the H-1 mine adits will be bulkheaded and backfilled and the adits at the P-13 and NJ-45 mines will be backfilled.

9. Revegetation Methods

A. Top Dresssing

Following final sloping and grading, pit bottoms will be top dressed with 24", waste dumps with 18" and all other areas within the minesite with 12" of material composed primarily of Tres Hermanos Sandstone (stockpiled at three locations within minesite). In order to meet top dressing volume requirements for the northern portion of the minesite, additional material may be obtained from a topsoil borrow area in the Rio Moquino floodplain comprising 44 acres. For the southern portion of the minesite, additional topsoil borrow material located east of J and H dumps may be needed. Following topsoil removal, disturbed borrow areas, will be contoured, fertilized, seeded and mulched.

B. Surface Preparation

After applying top dressing, areas to be planted will be fertilized, followed by disking to a depth of 8 inches and then contour furrowing.

C. Seeding and Seed Mixtures

Before seeding operations begin, the entire minesite will be fenced to prevent livestock grazing. In most situations, seed mixtures will be planted with a rangeland drill. Broadcast seeding combined with hydromulching may be used on inaccessible sites or if determined to be more feasible than drilling. For both methods, the seed mixture will consist mainly of native plant species possessing qualities compatible with post-grazing use and adapted to local environment (Tables 3-10 and 3-11, FEIS). Following drill seeding, straw mulch will be applied at about 2 tons per acre, and crimped into place with a notched disk.

D. Revegetation Success

Using the Community Structure Analysis (CSA) or comparable method, plant establishment will be considered success when revegetated sites reach 90 percent of the density, frequency, foliar cover, basal cover and production of undisturbed reference areas (but not sooner than 10 years following seeding). Livestock grazing will be prevented until 90 percent comparability values are met. At the end of the 10-year monitoring period, if an unsuccessful trend is shown retreatment may be necessary to achieve success criteria. In the pit bottoms, vegetation will be sampled annually for radionuclide and heavy metal uptake.

10. Monitoring

The monitoring period will vary for each parameter. Existing monitoring activities to be continued will include: meteorologic sampling, air particulate sampling, radon sampling (ambient), radon exhalation sampling, gamma survey, soil and vegetation sampling, water monitoring and subsidence. In addition, the monitoring program will be expanded to include: radon daughter levels (working levels) in any remaining mine buildings and ground water recover levels/salt build-up in the open pits. The ground water monitoring period will be of sufficient duration to determine the stable future water table conditions. Refer to Table 1-5 of the FEIS for details of the monitoring plan as described under the Preferred Alternative.

11. Security

Control of minesite access and security will continue during reclamation and monitoring activities. However, security during monitoring phase will require cooperation from Pueblo of Laguna and BIA to prevent livestock grazing on revegetated sites.

12. Reclamation Completion

Reclamation will be considered complete when revegetated sites reach 90 percent of the density, frequency, foliar cover, basal cover and production of undisturbed reference areas (but not sooner than 10 years following seeding). In addition, gamma radiation levels must be no greater than twice background over the entire minesite. Outdoor radon – 222 concentrations must be no greater than 3pCI/l. Radon daughter levels (Working Levels) in any remaining surface facilities must not exceed 0.03WL.

13. Post-Reclamation Land Uses

Limited livestock grazing, light manufacturing, office space, mining and major equipment storage will be allowed. Specifically excluded are habitation and farming.

## I. BACKGROUND AND OVERVIEW

OAS Systems Corporation (OAS) was tasked by the Pueblo of Laguna to perform an independent, third-party review and assessment of the overall conformance of reclamation activities carried out at the Jackpile-Paguate Mine (the "site") to those specific requirements as put forth in the site's 1986 Record of Decision (ROD) (*"Jackpile – Paguate Uranium Mine Reclamation Project Record of Decision"*, U.S. Department of the Interior, December 1986).

The Jackpile-Paguate Mine was primarily a multiple open-pit (3 pits) uranium mining operation developed on Pueblo of Laguna lands by the Anaconda Mining Company (previously Anaconda Copper Company). In late 1952, Anaconda negotiated exploration agreements and mining leases with the Laguna Indian Reservation, and mining commenced in 1953 at the Jackpile open pit, with operations subsequently expanding to include the North Paguate and South Paguate pit areas. Mined ore was transported approximately forty miles northwest to Anaconda's Bluewater Mill (northwest of Grants). In addition to open pit mining of uranium ore, Anaconda also conducted limited underground development and, circa 1969-70, pilot-scale applications of in situ uranium leaching utilizing sulfuric acid. At one time, the Jackpile-Paguate Mine was the largest open-pit uranium mine in the world. It produced 24 million tons of uranium ore. Four hundred million tons of rock was moved during the mining operation. Approximately 3,000 acres of the 7,000 acres leased were disturbed. Approximately 2,700 acres were reclaimed. Mining at the Jackpile-Paguate Mine was terminated in 1982 due to depressed uranium prices. Reclamation of the mine site commenced in 1990. Features such as roads, rivers, fence lines, dumps and monitoring points were added to a 2003 aerial photograph and a 1995 topographic base map to create Exhibits 1 and 2, respectively. These exhibits will be referenced frequently in this report.

## II. RECORD OF DECISION REQUIREMENTS

The need for reclamation of the mine was identified in the *"Jackpile-Paguate Uranium Mine Reclamation Project Final Environmental Impact Statement"*, Volumes 1 and 2 (FEIS), completed in October1986. The subsequent *"Jackpile-Paguate Uranium Mine Reclamation Project Record of Decision"* (the ROD) was jointly issued by the U.S. Department of Interior's Bureau of Land Management (BLM) and the Bureau of Indian Affairs (BIA), respectively, in December 1986. The ROD evolved primarily from analyses and findings detailed within the October 31, 1986 FEIS for the site, as prepared by BLM and BIA and filed with the U.S. Environmental Protection Agency (EPA). However, consideration of public comment and subsequent technical discussion and analyses among BLM and BIA specialists also contributed to defining the "preferred alternative" (and subsequently, the ROD). As a result, the ROD-specified "preferred alternative" represented a combination of reclamation procedures that best reflected or achieved the intent of the ROD "Decision Factors", more appropriately described as site reclamation objectives. The Decision Factors, in order of importance, were stated in the ROD to include the following:

- Ensure human health and safety;
- Reduce the releases of radioactive elements and radionuclei to as low as reasonably achievable;
- Ensure the integrity of all existing cultural, religious, and archeological sites;
- Return the vegetative cover to a productive condition comparable to the surrounding area;
- Provide for additional land uses that are compatible with other reclamation objectives and that are desired by the Pueblo of Laguna;
- Eliminate the need for post-reclamation maintenance;
- Blend the visual characteristics of the mine site with the surrounding terrain; and,
- Employ the Laguna people in efforts that afford them opportunities to utilize their skills or train them as appropriate.

In general, the "preferred alternative" reclamation plan incorporated the following components: (i) backfilling of open pit areas to at least ten feet above projected groundwater recovery levels using protore and waste rock dump material; (ii) slope reduction on the upper fifteen feet of pit highwall slopes; (iii) recontouring and covering of remaining waste rock dumps; (iv) completion of arroyo drainage improvements and erosion controls; (v) decontamination of those structures to remain, and removal/disposal of all non-essential structures; (vi) plugging and bulkheading of underground ventilation raises and decline portals, respectively; (vii) reclamation of miscellaneous features such as wells, access roads, rail spur, drill holes, etc.; (viii) site wide revegetation of disturbed areas; and, (ix) provision of site security and long-term monitoring of reclamation success for a period of not less than ten years.

Following successful negotiation of agreements with the Anaconda Mining Company (the prior operator of the Jackpile-Paguate Mine) and the U.S. Department of Interior, Bureau of Indian Affairs (as Trustee), the Pueblo of Laguna accepted the terms and conditions as described in the *"Cooperative Agreement Pursuant to "638"*, adopted on March 24, 1987, to Perform the Management, Coordination, and Administration of the Jackpile-Paguate Reclamation Project on the Laguna Indian Reservation, Cibola County, New Mexico *("Pueblo of Laguna, Reclamation Project Agreements, Section 3-Cooperative Agreement between the Bureau of Indian Affairs and the Pueblo of Laguna"* [Cooperative Agreement Pursuant to "638"], December 5, 1986. Thus, the Pueblo of Laguna was authorized to conduct all aspects of site reclamation at the Jackpile-Paguate Mine.

The Board of Directors for Laguna Construction Company (LCC) was established in June 1988 to reclaim the Jackpile Mine. Officers and key personnel were hired in late 1988 through early 1989. Approximately 10 million dollars worth of equipment was purchased for the project. The Jackpile reclamation began on August 15, 1989 and completed on December 31, 1995, one year ahead of schedule at a cost of approximately 45 million dollars.

As described above, the ROD prescribed specific actions to be carried out with respect to the various mine features. These actions were to be followed by site-wide revegetation of disturbed areas. Under the terms in the ROD, Section 12, Reclamation Completion, reclamation is to be considered complete when *"revegetated sites reach 90 percent of the density, frequency, foliar cover, basal cover, and production of undisturbed reference areas (but not sooner than 10 years following seeding). In addition, gamma radiation levels must be no greater than twice background over the entire mine site. Outdoor radon-222 concentrations must be no greater than 3 pico Curies/liter. Radon daughter levels (i.e., working levels or "WL") in any remaining surface facilities must not exceed 0. 0.03WL."*

## III. OAS APPROACH

Since there was no formal regulatory reporting during the reclamation and post-closure monitoring period, the first OAS endeavor was to assess and organize available data on the reclamation and monitoring activities. This was done by an initial site visit to the Laguna Pueblo to:

- meet with the Pueblo representatives ; Governor Roland Johnson, Chief of Operations Jim Hooper, and Environmental Manager Barbara Cywinska-Bernacik to formalize the scope of the project;
- meet with Jackpile – Paguate Mine Reclamation Project participants: BIA - Al Sedik and Laguna - Marvin Sarracino;
- review the available project documents; and
- tour the project site.

Prior to the meeting, OAS developed a matrix of ROD requirements versus likely data sources (Appendix A, Table A-1). Many of these sources proved to be unavailable. The Laguna Construction Company (LCC) organized its documentation around construction activities and work unit closeouts in order to justify progress payments. Without required periodic regulatory reporting requirements, there was no impetus to organize documentation around environmental requirements outlined in the ROD. Although, the Jacobs Engineering Group, Inc., *"Jackpile Project, Final Environmental Monitoring Plan"*, August 1989 (Jacobs Environmental Monitoring Plan) provided for annual Environmental Reporting, only a single annual report (1996) was found (Pueblo of Laguna, Reclamation Project Manager, *"Jackpile Reclamation Project, Pueblo of Laguna, New Mexico, Annual Report"*, 1996). Likewise, only a single quarterly report was located (*"Jackpile Reclamation Project, Pueblo of Laguna, New Mexico, Environmental Monitoring and Regulatory Compliance, Status Report No. 20"*, December, 1994-February, 1995). A tactical modification was made to try to piece compliance through other sources that included raw lab and field data, construction work unit reports and letter authorizations, field inspections and photographs, and verbal testaments of activities by project personnel.

**SUBSTANTIATING ROD COMPLIANCE**

PRIMARY – (1) Review Field and Lab Data

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PRIMARY – (2) Review Documents (Letters, Monthly Reports, and other Reports)

↓

SECONDARY – (3) Check Work Unit Sign-offs and Approved Expenditures

↓

SECONDARY – (4) Review Photographs (Aerials and others)

↓

TERTIARY – (5) Gather Statements from Project Professionals

As with most construction projects, a work breakout schedule was established, which quantified construction activities. There were approximately 300 work items tracked. Physical locations that were called out one way in the EIS and ROD were broken down into sub areas and renamed to match the Reclamation Project work breakout. OAS reviewed the EIS maps and compared those to the maps within the Project Status Report and devised a comparative table to identify work areas to EIS designated areas (Appendix A, Table A-2). OAS also generated a matrix that relates the work units to the ROD areas (Appendix A, Table A-3).

The monthly reclamation Project Status Reports were submitted to the POL throughout the reclamation period. There are 71 Project Status Reports, which are organized around work items. These reports contained maps of various work areas, percent completion within the work areas, photos of noteworthy activities, problems identified, change orders, and work item closeouts.

There are discussions within the Project Status Reports of design changes and variations that *"meet the intent of the ROD"*. These are generally in the form of letters of transference of a design change or discussion forwarded to the BIA and POL for review or approval. The design packages that were actually submitted were not attached to the Project Status Reports that OAS received. When a reference to a letter of approval was discussed in the Project Status Report, it was impossible to link that acceptance to a specific design change. There were no letters available with attachments that stated that there was a deviation from the ROD requirement and delineating the accepted change with a three party signature. The Change Orders listed were for quantity changes that affected the contract price.

As each work item was completed, field inspections by the three agencies (Pueblo of Laguna, Bureau of Indian Affairs, and Laguna Construction Company) were conducted and all three agencies signed off on each work item, signifying agreement with the manner of the work, completeness of the work and payment approval. This is the only formal documentation of approvals of work that could be found. Pueblo of Laguna, "*Jackpile Reclamation Project, Pueblo of Laguna, New Mexico*", Volume 1 of 2 – Completed Work Packages, 1989-1991, contains the signoff forms from the 3 agencies approving closeout of a work item and payment approval. Volume 2 of 2 was never located. To supplement this document, OAS reviewed each Project Status Report and logged whether activity took place on that work unit and if it was listed as closed out. The matrix tracking the work unit progress is presented in Appendix A, Table A-4. This table is used to indicate the approval of the work by the three agencies, each of who had a field inspector. Absent more direct documentation, OAS has used the Project Status Report summaries to indicate that the parties involved signed off on the work as either conforming to the requirements of the ROD or an authorized deviation from the ROD.

## IV. ROD COMPLIANCE

Most current RODs are prepared in a manner that specifies certain environmental criteria that must be met, but do not specify the methods required to meet the environmental goals. The Jackpile ROD was written in a different manner in that it specified certain engineering approaches that were to be initiated during reclamation, which would meet the goal of stability and the protection of human and animal health and safety rather than specifying environmental compliance thresholds. Consequently, there were some difficulties in determining if compliance with the ROD items was met. There were instances in which the letter of the ROD was met but the intent was not met. Conversely, there were cases in which the letter of the ROD was not met, but the intent or goal of the ROD was met.

For an example of the first instance, the ROD specified that an erosion control structure was to be installed along the Rio Moquino. The structure was installed as required, but the bank below the toe of the waste pile is eroding in spite of the control structure. If the erosion continues, the waste pile could be compromised at some time in the future, which is contrary to the intent of the ROD.

There are also a couple of examples that were evaluated in which the prescribed engineering design was not performed, but in which the goal of the ROD was met. The first involved an area on the Rio Moquino where a structure designed to prevent headcutting was not installed, but the in situ sandstone formation prevented further erosion. A second instance where the letter of the ROD was not followed but the intent was met, was where a gabion drop structure was to be installed on the Rio Moquino at a road crossing. The Rio Moquino washed out of its old channel and the rivers' new channel does not require an erosion control structure to prevent exposure of the waste pile.

In general, the purpose of the OAS evaluation of whether the approach to each ROD item was compliant or non-compliant, was to determine whether the intent of the ROD was met rather than the letter of the ROD.

In this section, the ROD is examined point by point for compliance. Where there is direct proof of compliance it is presented and referenced. Where there is deviation from the ROD, justification is presented where there is authorization documented or implied through contractual signoffs. If there appear to be unauthorized deviations, then discussions present potential impacts of the deviation.

It should be noted that the Reclamation Team recognized that strict compliance to the letter of the ROD was not anticipated, as reflected in the following from a May 9, 1990 summary of recommendations that were forwarded to the POL Council and BIA for approval. (*"Jackpile Reclamation Project, Final Design Recommendations for BIA Approval"*, May 9, 1990, pg 2, ¶ 4).

> *"These items are felt to be within the "spirit" of the ROD and consistent with the Decision Factors (Page 3 of the ROD) but may not necessarily be to the "letter" of some of the specifics in the ROD Measures. However, enough new information has become available to the responsible parties on the Project (from late 1989 to the present) which have identified opportunities to better meet the longer term goals and objectives in a more cost-effective way utilizing current industry practice. Many of the design conditions have changed since the early and mid-1980's; field conditions at the Jackpile site have been identified which make compliance with the "letter" of the ROD virtually unachievable in some cases and financially burdensome to the POL in others."*

**ROD Requirements**

The ROD requirements are presented in ***Bold Italics***.

1. ***PIT BOTTOMS***

   A. ***Backfill Levels:***

      1. ***Pits will remain as closed basins. Pit bottoms will be backfilled to at least 10 feet above the Dames and Moore (1983) projected ground water recovery levels as indicated below. A schematic diagram is shown in the FEIS, Appendix A (Figure A-1, DOI Proposal):***

| ***Pit:*** | ***Proposed Minimum Backfill Level:*** |
|---|---|
| ***Jackpile 41*** | ***5,939 ft. amsl*** |
| ***North Paguate 20*** | ***5,958 ft. amsl*** |
| ***South Paguate 34*** | ***5,995 ft. amsl*** |
| ***South Paguate 35*** | ***6,060 ft. amsl*** |

The minimum back fill levels can be confirmed by the survey data presented for ground elevations at the pit wells. The LCC provided the following survey information for the monitoring wells installed in the North and South Paguate Open Pits. Additional wells were installed in the Jackpile Pit in April 2007.

**Table 1**
**Monitor Well Survey Information**

| WELL ELEVATION | | | TAKEN: 3-31-92 By: LCC, Inc. | |
|---|---|---|---|---|
| LOCATION | N | E | GROUND ELEVATION | TOP CAP ELEVATION |
| North Paguate NP-OP-20 W | 1,504,823.95 | 638,745.96 | 5966.2 | 5968.17 |
| North Paguate NP-OP-20 E | 1,505,123.28 | 641,582.11 | 5961.85 | 5963.93 |
| South Paguate SP-OP-34 | 1,500,641.39 | 637,928.55 | 5995.04 | 5997.84 |
| South Paguate SP-OP-35 | 1,501,033.20 | 634,954.17 | 6060.89 | 6031.21 |
| Jackpile JP-OP-41 S | 1,505,868.90 | 648,232.78 | 5939.80 | 5943.40 |
| Jackpile JP-OP-41 N | 1,508,348.33 | 649,080.80 | 5937.37 | 5941.07 |

Based on these provided surveyed finish grade ground elevations at the monitoring wells in the Paguate pits, the elevations match or exceed the minimum elevations proposed by Dames & Moore in the ROD.

**Conclusions** – All monitoring well installation indicate that the minimum finished grades were achieved.

**Recommendations** - Based on the fact that backfill elevations in all cases met or exceed the minimum proposed backfill level(s), the ROD objective has been achieved.

2. ***A groundwater recovery level monitoring program will be implemented. Additional backfill will be added as necessary to control ponded water. The duration of the monitoring program will be a minimum of 10 years.***

This item requires that monitoring be performed to assure that the ROD projections were accurate in predicting groundwater elevation recovery levels. There were only four years of groundwater elevation data found for the North and South Paguate Pit Wells. The Jackpile wells were installed in April 2007 and sampling for 2007 indicates all pit wells, except NP-OP-20W, met the 10-foot separation required in the ROD. The NP-OP-20W well was found to have a groundwater elevation of less than five feet consistently, as indicated in bold in the following table.

**Table 2**
**Groundwater Elevations in Pits**

| Wells | NP-OP-20E | NP-OP-20W | SP-OP-34 | SP-OP-35 | JP-OP-41N | JP-OP-41S |
|---|---|---|---|---|---|---|
| **Dates** | | | | | | |
| **1996** | | | | | | |
| **1997** | | | | | | |
| **1998** | | | | | | |
| **1999** | 29.91 | **3.88** | 19.4 | 75.5 | | |
| **2000** | | | | | | |
| **2001** | | | | | | |
| **2002** | | | | | | |
| **2003** | | | | | | |
| **2004** | 31.87 | **4.35** | 18.15 | 81.33 | | |
| **2005** | 31.62 | **3.29** | 17.6 | 71.57 | | |
| **2006** | 31.4 | **3.33** | 17.46 | 70.88 | | |
| **2007** | 31.80 | **4.22** | 19.04 | 70.86 | 32.85 | 38.99 |

*Blank fields indicate no data was provided*

**Discussion** - From the OAS site inspection, there is a permanent pond/wetland area in the North Paguate pit. A photograph of this ponded area is found in Appendix B, Photo B-1. This photo contains the NP-OP-20W well shown near the ponded area. The water table elevation of that well is not compliant with the ROD. The ponding is also evidenced by aerial photos (Appendix E) and established wetland vegetation species. Although, the Jacobs Environmental Monitoring Plan required that all ponded water within the pits be monitored annually for chemical constituents, there was no water quality data for this ponded area. A sample was collected from the NP Pond in 2007 which indicates elevated concentrations of radiologicals. These results are discussed in Section 10-Monitoring. Additional sampling and assessment of this situation will be needed to draw conclusions on the risk to humans, wildlife or domestic stock.

2006 was a very wet year with significant standing water in all three pits for most of the summer's duration.

**Conclusions** - Based on the fact that there is little elevation data where ten years of data are required and only one sample of the ponded water, accordingly, this aspect of site reclamation is considered ***non-compliant*** with the requirements of the ROD.

**Recommendations** -

- During preparation of this report, OAS made the recommendation that the two wells required by the ROD should be installed in the Jackpile Pit. This was done in April 2007
- Water table elevations should be monitored over a number of years to determine if the levels have stabilized, or are increasing or declining in order to evaluate whether the 10-foot below surface requirement is being met.
- Ponded water, wherever found within the pits, should be collected for chemical and radiological analysis.

These data can then be used to assess the risk of ponded water. The data can then be analyzed to determine if the water is groundwater or surface water and whether the chemical constituents or radiological levels present a threat to wildlife, domestic stock, or humans. As wetland areas are diverse ecosystems that are widely valued, it may be prudent to leave the North Paguate area as a wetland if the risk analysis so justifies. If chemical or radiological analysis indicates an unacceptable risk, then the ROD requirement to add additional fill to low areas would be warranted.

## B. *Backfill Materials:*

***Backfill materials will consist of protore, waste dumps H and J, and excess material obtained from waste dump resloping and stream channel clearing. These materials will be covered with 3 feet of overburden and 2 feet of topsoil (i.e. Tres Hermanos Sandstone or alluvial material).***

Waste Dumps H and J were not moved into the pits. Per M. Sarracino, their volumes were not required and the distance to move them was deemed prohibitive. Waste Piles H and J were sloped/terraced/seeded. Photos B-2 and B-3 show stable, vegetated waste piles H and J, respectively.

Project Status Reports document protore movements in the North Paguate, (Report No. 20), South Paguate (Report No. 26) and Jackpile (Report No. 43) Pits.

Activity codes in group 2E1 were authorized for payment for backfill movement. Table A-3, Appendix A, delineates which protore and waste piles were affiliated with which work units. Based on the Project Status Reports, backfilling took place in the following time frames:

| | |
|---|---|
| Jackpile Pit | May 1991 through December 1994 |
| North Paguate Pit | November 1991 through April 1991 |
| South Paguate Pit | September 1990 through September 1991 |

There were approved design changes for required cover depths that are described later in Section 3c.

**Conclusions** - Although, Dumps H and J were not moved, there appears to be substantial compliance to the ROD. There was sufficient backfill material in proximity to the pits that Dumps H and J volumes were, in fact, not needed. The cover, slopes, and vegetation on these waste piles appear to be stable.

**Recommendations** – No further activities are recommended at this time.

## C. *Stabilization:*

***All backfill slopes will be reduced to no greater than 3:1 (horizontal to vertical). Surface water control berms will be constructed within pit bottoms to reduce erosion and retain soil moisture for plant growth. Surface runoff will also be directed to small retention basins in the pit bottoms. All areas in the pits will then undergo surface shaping, topsoil application, and seeding as outlined under "Revegetation Methods" below.***

### 1. Sloping

Project Status Report No. 11, dated June 1990, included remarks relating to changes in the sloping requirements listed in the ROD. This includes summary milestones (Section 2.4 MILESTONES):

- *"Michael Bone, P.E. of Roy F. Weston, Inc. submitted the final design criteria for slope heights, lengths, and terracing specifications."*

- *"Water Mills (Acting Asst. Secretary, Bureau of Indian Affairs, Washington, D.C.) formally approved the design changes submitted to George Farris in May 1990. These design changes will be incorporated into all future planning efforts."*

Project Status Report No. 11 also contains a memorandum (attachment) received June 12, 1990 from Acting Assistant Director of Indian Affairs, Walter Mills approving the design changes (pg 2, ¶ 2 & 3):

*"On May 15, 1990, a new reclamation design criteria was presented by Landmark/Weston for BIA approval. This design criteria is important in that it sets basic design criteria while allowing for the flexibility necessary for the LCC and the Bureau to make some decisions on a case-by-case basis. The re-design will also eliminate the long slopes that are now required and at the same time result in a more stable slope design. This will also allow the project to blend more aesthetically with the surrounding topography.*

*Because we view this as an improvement on the existing design, I hereby approve the criteria set forth by Landmark/Weston on May 15. If there are any questions or if you need further assistance on this matter, please contact Mr. George R. Farris at FTS 268-4791."*

**Conclusions** - There appears to be ***non-compliance*** to the letter of the ROD requirements in regard to the sloping. But many deviations were approved. It is difficult to determine pile by pile what exactly was done according to the ROD 3:1 sloping requirement and/or in accordance with the approved changes. In the OAS site inspection, there were no observed problems with the slope grades. Although there are deviations to the ROD, they appear to have met the intent of the ROD.

Some of the long runs of the terracing do appear to cause chronic blow-outs in some areas due to the pressure head of water building up along the terrace berm. The terracing problem is further discussed in Section 3c of this report.

**Recommendations** - There are no corrective actions recommended

**2. Pit Berms and Retention Ponds**

After reclamation was complete, the pit bottoms were contoured and there is no evidence that berms or retention ponds were installed. Therefore, it is unknown if that was done during reclamation.

**Conclusions** – The pit berms and retention ponds are not believed to be a concern for post closure health and environmental risks.

**Recommendations** – No further activities are recommended.

**D. *Post-Reclamation Access:***

***Human and animal access to pit bottoms will be prevented with the use of sheep-proof fencing due to the uncertainties of predicting radionuclide and heavy metal uptake into plants (forage).***

The reclamation construction specifications (Jacobs Engineering Group, Inc., "*Jackpile Project, Construction Specifications*", August 1989) detailed a different type of fencing: four strand barbed wire, as shown in the project specifications. (Division 2, Sitework, Section 02833, Fences and Gates, pg. 2-36)

*"2.1 MATERIALS*

*A. Reusable materials salvaged from demolition work specified in Section 02060 shall be utilized, to the extent practical, in the construction of the fence and gates specified in this section.*

*B. Fencing shall include posts, barbed wire, and all appurtenances and accessories required for complete installation.*

*C. Barbed wire shall conform to the requirements of ASTM A121, and shall consist of four lines of double stranded 12 ½-gage galvanized wire with* *either 2-point or 4-point barbs spaced at 5-inch intervals. Galvanizing shall be Class 3.*

*D. Line post shall be galvanized tee, channel, or U-bar shapes, 1.33 pounds per foot.*

*E. Braces shall be 9-gage wire, twisted to tighten.*

*F. End, corner, and pull posts shall be 2-inch Schedule 40 galvanized steel pipe, or galvanized steel angle section 2 ½ x 2 ½ x ¼ inches.*

*G. Hardware for connecting members shall conform to commercial standards."*

The fencing installed appears to be on the perimeter of the mine site rather than the pit bottoms. The fencing is the four strand barbed wire rather than the sheep-proof fencing called for in the ROD. Photo B-4 in Appendix B, is a photo taken of the fencing as it was installed in September 1990.

Based on Project Status Report No. 32, March 1992, and sightings during inspections of the site in 2006, there appears to be ongoing problems with cattle and horses entering the mine site in general, and the Jackpile pit bottom in particular. The existing fencing does not impede access of domesticated or wild animals.

The OAS 2006 report *"Jackpile-Paguate Uranium Mine Post-Reclamation, Soils and Plant Uptake Analysis"* concludes that vegetation growing on the reclaimed mine presents a minimal potential for hazards to domestic livestock or human health due to the low or normal concentrations of metals and radionuclides.

Based on sampling of the monitoring wells in the North Paguate and South Paguate pits, and the newly installed Jackpile wells, there are very high concentrations of radionuclides in the groundwater. Similarly, the 2007 sampling of the NP Pond indicates high concentrations of radiologicals in that surface water feature, which is readily accessible to grazing animals. Limited well construction information or water table elevation data were available, so conclusions cannot be drawn as to whether the water is surface water in origin, perched water, or true groundwater. Further investigation is necessary to determine the risk involved from access by humans or animals.

**Conclusions** - There appears to be substantial ***non-compliance*** with both the letter and intent of this Rod requirement. The fencing is clearly inadequate to prevent grazing. Installation of the perimeter fencing was approved in 1989. The perimeter fencing cannot be removed and should be maintained. One or two additional sampling events need to be conducted in the North Paguate pit. Additional backfilling or permanent fence installation at North Paguate may be required based on those sampling events.

**Recommendations** – Additional monitoring and risk assessment is required to determine if there is any potential for impairment to the natural resources (both water and vegetation) that are needed for grazing domestic animals and wildlife. Pit bottoms need to be fenced until a recommended risk assessment is completed.

## 2. *PIT HIGHWALLS*

### A. *Jackpile Pit Highwall:*

***The top 15 feet of highwall will be cut to a 45-degree slope. All soil and unconsolidated material at the top of the highwall will be sloped 3:1. The highwall will be scaled to remove loose debris.***

### B. *North Paguate Pit Highwall:*

***The top 15 feet of highwall will be cut to a 45-degree slope. All soil and unconsolidated material at the top of the highwall will be sloped 3:1. The highwall will be scaled to remove loose debris. Additionally, the highwall will be fenced with 6-foot chain link.***

### C. *South Paguate Pit Highwall:*

***The top 15 feet of highwall will be cut to a 45-degree slope. All soil and unconsolidated material at the top of the highwall will be sloped 3:1. The highwall will be scaled to remove loose debris. Additionally, the highwall will be fenced with 6-foot chain link.***

The Jacobs Environmental Monitoring Plan states that blasting to reduce highwall slopes will be considered "OPTIONAL" work package items dependent on funding and POL desires.

Work on the highwalls started with the highwalls of the South Paguate Pit. There were objections to the blasting from the Paguate Village. Project Status Report No. 9, April 1990, references a Seismic Study and Project Status Report No. 11, June 1990, a Blast Study documenting damage too many of the buildings in the Village. Photos B-5, B-6, and B-7 in Appendix B, show present day conditions of several of the highwalls.

There is a two page document entitled *"Jackpile Reclamation Project, Final Design Recommendations for BIA Approval"* dated May 9, 1990, which summarizes several design variations. A signed copy of approvals and authorizations was not found. The following excerpt relates to the highwalls (pg. 2, ¶ 1).

> *"7) Some highwall trimming and scaling is seen as unnecessary and infeasible in some cases due to natural stabilization along alluvial material (mostly in the South Paguate-west end) and lack of safe access (places to*

*safety situate heavy equipment). Along the Jackpile pit crest on Gavilan Mesa (where the presence of extremely competent Tres Hermanos Sandstone has showed no visible weathering or hazardous conditions) the trimming requirement would require blasting. Blasting has already had to be used to stabilize a portion of the South Paguate pit, but objections from the Pueblo on the use of blasting have precluded any future use of it for trimming or scaling."*

A memorandum dated April 23, 1991 from J.H Olsen, Jr. to Governor Harry Early documented POL Council approved design changes and recommended forwarding description of changes to the BIA for approval. A signed copy of the approvals and authorizations was not found. One of the changes was to abandon the highwalls and allow them to erode naturally. The following is the relevant excerpt from the 1991 memorandum. (*"Pueblo of Laguna Council, Reclamation Project Issues"*, April 23, 1991, pg. 3, ¶ 2)

*c) HIGHWALL TRIMMING & SCALING*

*Evaluation of the highwall trimming and scaling requirement has prompted questioning of its need and value. Operationally, the activities are extremely difficult to achieve because of inaccessibility and risk to equipment operators. Experience with drilling and blasting techniques in the spring, 1990 proved objectionable due to the potential blast damage in Paguate. (Many highwalls could only be trimmed and scaled with blasting techniques due to the presence of hard sandstone materials on the highwall crests and the danger of putting heavy equipment next to the edges.) Scaling probably loosens up more material than it effectively removes. Trimming of the crests would also enhance erosion since runoff would have more surface area on which to collect and run off. It is recommended that trimming and scaling requirements be suspended since it is judged that, over time, the highwalls will revert to a stable state much the same as natural mesas adjacent to the site which are composed of the same geologic materials. As mentioned, drilling and blasting is the only way to trim and scale some highwalls and the blast damage to structures in Paguate could actually aggravate the problem experienced from the active mining area. The unspent funds from this activity could be used to help repairing already-identified damage."*

Work Units covering the trim and scaling of highwalls are 2E5. All work on these activities ceased in December 1991.

Four-foot high chain link fence was installed in the South Paguate area that was blasted. No fencing was observed in any other highwall areas.

**Conclusions** - This aspect of site reclamation is considered compliant with the desires of the Pueblo of Laguna and the deviation from the ROD requirements is well substantiated with the results of the blast studies. The Jacobs

Environmental Monitoring Plan listed this approach as an option that could be based on the wishes of the Pueblo of Laguna.

**Recommendations** - A field assessment of the highwalls and Old Highway 279 should be made periodically to make sure that the highwalls do not comprise a threat to normal Pueblo of Laguna activities, or if additional fencing or other corrective measures are required during the erosion process. If significant hazard potential is present, other means of slope reduction should be evaluated, such as ripping, or alternatively, localized berming or other protective measures may be warranted. The south-facing wall at the North Paguate pit also needs to be periodically assessed to assure that it is eroding sufficiently to cover the exposed Jackpile Sandstone, as planned.

## 3. *WASTE DUMPS*

### *a. Waste dumps H and J will be relocated to Jackpile pit as backfill.*

As discussed in ROD Requirement C above, Waste Dumps H and J were not moved into the pits. Their volumes were not required and the distance to move them was deemed prohibitive. Waste Piles H and J were successfully sloped, terraced and seeded.

### *b. Most dump slopes will be reduced to 3:1 or less and the dump slopes will be contour furrowed; exceptions are noted in Table I-4 of the FEIS.*

As discussed in ROD Requirement C, there are references in several Project Status Reports (Reports No. 1, 6, 7, 9, 11, and 13) regarding variations to 3:1 sloping of waste piles.

A memorandum dated April 23, 1991 from J.H Olsen, Jr. to Governor Harry Early (*"Pueblo of Laguna Council, Reclamation Project Issues", April 23, 1991)* documented POL Council approved design changes and recommended forwarding description of changes to the BIA for approval. A signed copy of the approvals and authorizations was not found. Some of the changes related to deviations from the 3:1 sloping criteria. The following are the relevant excerpts from that memorandum.

**Jackpile Area** - (pg. 2, ¶ 1, 2 & 3)

*"SPECIAL CASE DESIGN NO. 2- JACKPILE WASTE DUMP JP-WO-03: This dump was originally to be sloped at 3:1 and placement of more topsoil over the entire area. The top of this dump already meets the revegetation standards and as much as is practical will be salvaged when the 3:1 slope is cut. Grading to help channel the runoff to eliminate long term erosion in this area will help its stability. The revised design cost is estimated at this time to be equal to the Jacob's estimate of $330,000 for the sloping work.*

*"SPECIAL CASE DESIGN NO. 3- JACKPILE WASTE DUMP JP-WS-19: This dump, when sloped to 3:1 would move material off the site onto the Cebolletta Land Grant. To avoid this, the top of the dump will be moved southward into the Jackpile Pit until the height is reduced to allow for 3:1 sloping and keep this material on the Project Site.*
*Estimated cost for the sloping work is $540,000.*

*"SPECIAL CASE DESIGN NO. 4- GAVILAN MESA DUMP JP-WS-01: This dump cannot be dozed to 3:1 without blasting the existing mesa which is in the backslope. No provisions for blasting costs and its associated potential shock effects had been made in the original design. This is the most visible dump on the site and the visual characteristics of the finished slope needed to be considered. The recommended approach is to cut the top of the dump down to a level where the natural mesa is exposed; this will blend in with the surroundings and the remaining material will be sloped down to the 3:1 criteria and revegetated. Estimated cost at this time is judged to equal the Jacobs estimate of approximately $340,000."*

<u>**South Paguate Area**</u> - (pg. 2, ¶ 4)

*"SPECIAL CASE DESIGN NO. 5- OAK CANYON WASTE PILE SP-WO-06: This dump is north of the LCC shop area and runs along the north side of the Oak Canyon. Sloping of this dump to the 3:1 criteria had several difficulties: destroying and covering up the natural conditions in the canyon, upsetting the already-stable dump by increasing the potential for water runoff, original work schedule for this effort interfered with the topsoil stockpile removal, and the presence in certain spots of natural rock outcroppings which could not be done with existing equipment. The recommended treatment is to leave the dump as is and increase the vegetative cover using hydroseeding techniques. If this operation is not adequate, future sloping and additional topsoil placement could be done at the POL's direction.*
*Elimination of the sloping/soil cost in the Jacobs estimate is offset by the revegetation expense."*

Although the letter of the ROD was not met, the approved modified methods (i.e. sloping) appear to have been put in place successfully. There have been no observed problems associated with the modifications that were implemented.

c. ***Dumps which have Jackpile Sandstone on their outer surface and any Jackpile Sandstone exposed during resloping will be covered with 3 feet of overburden and 18 inches of topsoil.***

The cover requirement for the Jackpile Sandstone was reduced to a 1.0-foot radon cover and 1.5 feet of soil by the construction specifications, as shown below. (Jacobs Engineering Group, Inc. *"Jackpile Project, Construction Specifications"*, August 1989 – Division 2, Sitework, Section 02000, Earthwork, 3.5 Fill Construction, pg. 2-16)

"4. *Cover Construction:*

a. *The Contractor shall place cover material at the locations and related thicknesses shown on the drawings. The requirements listed in Table 1 shall be followed unless otherwise shown on the drawings or directed by the Engineer:*

***TABLE 1***

| ***Surface Material Thickness*** | ***Radon and Soil Cover*** |
|---|---|
| *Mancos Shale* | *Soil – 1.5 ft.* |
| *Tres Hermanos Sandstone* | *None required* |
| *Alluvium* | *None required* |
| *Jackpile Sandstone - Ore Associated Waste (greater than 40 percent of total area – outside of pit)* | *Radon Cover – 1.0 ft.*<br>*Soil – 1.5 ft.* |
| *Jackpile Sandstone - Ore Associated Waste (greater than 40 percent of total area – inside of pit)* | *Radon Cover – 1.0 ft.*<br>*Soil – 2.0 ft.* |
| *Jackpile Sandstone - Protore (inside of pit)* | *Radon Cover – 1.0 ft.*<br>*Soil – 2.0 ft.* |
| *Mixed Material (Jackpile Sandstone less than 40 percent of total area)"* | *Soil – 1.5 ft.* |

**c.(1) <u>Shale Cover</u>**

The ROD required numerous areas to be covered with a radon barrier of shale prior to placement of topsoil. The requirements of the ROD are listed in the following table. These areas included both in situ ore left un-mined inside the pits and locations outside the pit from where protore was moved inside the pit. The reclamation team field verified shale layer depths and their measurements are summarized below. The field sheets from which these data were summarized are included in files labeled 'Shale Cover Data' in the project electronic library. The list was reviewed by M. Sarracino, and it appears to be comprehensive and the finished depths in compliance with the ROD requirements.

**Table 3**
**Shale Layer for Radon Cap, Field Verification Depths**

| LOCATION Measured | JSS-Ore Inside Pit (min. 12") | Protore (min. 12") | Mixed Material (min. none) | Radon Barrier Shale Depth (inches) | | Gamma after Shale Placement (mR/h) * |
|---|---|---|---|---|---|---|
| NP-D3-D2 | X | | | min | 12 | 13.7 |
| | | | | max | 13.71 | |
| NP-PS-13 | | X | | min | 12 | No Data |
| | | | | max | 14.14 | |
| NP-PS-14, 15 | | X | | min | 12 | 20.5 |
| | | | | max | 12.7 | |
| SP-PS-01 | | X | | min | 12 | No Data |
| | | | | max | 13.07 | |
| SP-PS-02 | | X | | min | 12 | 13.8 |
| | | | | max | 12.3 | |
| SP-PS-38 | | X | | min | 12 | No Data |
| | | | | max | 12.7 | |
| SP-WO-04 | | | X | min | 12 | 10.9 |
| | | | | max | 13.43 | |
| SP-WO-10 | | | X | min | No Data | No Data |
| | | | | max | No Data | |
| SP-WO-13 | | | X | min | 12 | No Data |
| | | | | max | 14.1 | |

* *Target Gamma concentration after cover placement was less than 2 times background (14 mR/h)*

**c.(2) Topsoil**

The ROD required numerous areas to be covered with Top Soil to a specified depth. The requirements of the ROD are listed in the Table 4. The reclamation team field verified top soil layer depths and their measurements are summarized below. The field sheets from which these data were summarized are included in files labeled 'Soil Cover Data' in the project electronic library.

Four categories of areas are listed in Table 4:

1.) Mancos Shale - Areas with the letter "S" opposite them are areas that served as sources of shale for radon barrier material. After the material for cover was removed these required 18" inches of topsoil according to the ROD. This appears to have been confirmed.
2.) JSS-Ore Inside Pit – These are areas of in situ un-mined Ore inside the pit which was covered with shale in an earlier step and required 24" of topsoil according to the ROD. There appears to be a deviation from the ROD and a targeted depth of 18 inches of topsoil for this category. It is unclear if this is a documented approved change in requirements.
3.) Protore - Protore stockpiles were placed into the pit and their locations documented for potential future use. These areas like the un-mined ore required

24 inches of topsoil on top of the shale radon barrier. There appears to be a deviation from the ROD and a targeted depth of 18 inches of topsoil for this category. Again, it is unclear if this is a documented approved change in requirements.

4.) Mixed Material – These areas are waste piles outside the pit that were sloped/contoured and covered with 18 inches of material. This is in accordance with the ROD and the depths were confirmed. Within the fourth category is a top soil source area marked "T". This was an area where topsoil was mined for cover. It is an area that should require no cover and not be covered by the ROD.

**Table 4**
**Top Soil Layer, Field Verification Depths**

| Location Measured | EIS Map Label | Mancos Shale (min.18") | JSS-Ore Inside Pit (min.24") | Protore (min.24") | Mixed Material (min.18") | | Top Soil Depth (inches) | Gamma After Shale Placement (mR/h) |
|---|---|---|---|---|---|---|---|---|
| JP-PS-24 | SP 6a | | | X | | min | 20 | |
| | | | | | | avg | 21.7 | |
| JP-WO-06 | H | | | | X | min | 18 | |
| | | | | | | avg | 19.4 | |
| JP-WO-05 | J | | | | X | min | 18 | |
| | | | | | | avg | 20.5 | |
| JP-D12 | ??? | | | | X | min | 18 | |
| | | | | | | avg | 20.2 | |
| JP-WS-17 | FD-1 | S | | | | min | 18 | |
| | | | | | | avg | 18 | |
| JP-WT-16 | ??? | | | | T | min | 18 | |
| | | | | | | avg | 18 | |
| JP-PS-27 | J1 | | | X | | min | 18 | |
| | | | | | | avg | 18 | |
| JP-WS-15 | A & B | S | | | | min | 18 | |
| | | | | | | avg | 18 | |
| JP-OP-41 | Pit Bottom | | X | | | min | 18 | |
| | | | | | | avg | 18 | |
| NP-D1 | Pit Bottom | | X | | | min | 18 | 10.6 |
| | | | | | | avg | 19.8 | |
| NP-D-2&3 | Pit Bottom | | X | | | min | 18 | |
| | | | | | | avg | 21.0 | |
| NP-D4, NP-PS-13 | SP-1 | | | X | | min | 18 | |
| | | | | | | avg | 20.83 | |
| NP-PS-16 | 10. SP-2-D, SP-1-C | | | X | | min | 18 | |
| | | | | | | avg | 20.77 | |
| NP-D-5 | NP-PS-14, 15 | | | X | | min | 18 | |
| | | | | | | avg | 19.7 | |
| SP-CS-38 | K & L | | | | X | min | 18 | 10.65 |
| | | | | | | avg | 19.77 | |
| SP-WO-04 | Q & R | | | | X | min | 18 | 18.46 |

| Location Measured | EIS Map Label | Mancos Shale (min.18") | JSS-Ore Inside Pit (min.24") | Protore (min.24") | Mixed Material (min.18") | | Top Soil Depth (inches) | Gamma After Shale Placement (mR/h) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | avg | 20.7 | |
| SP-OP-34 | Pit Bottom | | X | | | min | 18 | 14.34 |
| | | | | | | avg | 19.11 | |
| SP-OP-35 | Pit Bottom | | X | | | min | 18 | 13.9 |
| | | | | | | avg | 20.8 | |
| SP-WS-18C & 20 | | S | | | | min | 18 | 13.9 |
| | | | | | | avg | 18.5 | |
| SP-PS-01 | SP-1A | | | X | | min | 18 | |
| | | | | | | avg | 21.1 | |
| SP-PS-02 | 4-1 | | | X | | min | 18 | 9.6 |
| | | | | | | avg | 19.6 | |
| SP-WO-10 | Pit Bottom | | | | X | min | 18 | 10.13 |
| | | | | | | avg | 21.17 | |
| SP-WO-13A | Pit Bottom | | | | X | min | 18 | 9.1 |
| | | | | | | avg | 18.9 | |
| SP-WS-37 | Pit Bottom | S | | | | min | 18 | |
| | | | | | | avg | 20.11 | |

The topsoil covers were placed on sloped and contoured surfaces and then seeded. The target cover depth for all areas appears to have been 18 inches and 18 inches were achieved The target of less than 2 times background (with background 14 mR/h) appears to have been achieved in areas where it was monitored.

d. ***Berms will be installed on all dump crests to control erosion. All dump tops will slope slightly away from their outer slopes. Dump slopes will be contoured so their toes are convex to prevent formation of major gullies on slopes.***

Erosion control berms were installed. As shown in an early photograph from Project Status Report No. 14, September 1990, Figure 6, B-8 shows the berms as constructed and recent OAS 2006 photos B-9 and B-10, Appendix B, indicate that they continue to retain precipitation event runoff.

**Discussion** - The berms and contouring are working well except in limited cases where the excessive berm length causes too large a buildup of water resulting in predictable, chronic blow-out areas. Photos B-11 and B-12, Appendix B, show areas of chronic blowouts, due to water build up on long berm runs. The locations presented in Table 5 have been observed by M. Sarracino and Laguna Construction Company (LCC), to have chronic erosion problems. Maps indicating these areas are presented in Appendix C (Exhibits 1 and 2).

**Table 5**
**Areas with Chronic Erosion Problems**

| LOCATION | DESCRIPTION |
|---|---|
| Jackpile Area: | Area Y, Y2, X along terraces at, or around, transitions between piles |
| | Area A, B, FD-3 along terraces at, or around transitions between piles |
| | Area W & V at the drainage areas against natural mesa |
| | JP-WS-17, JP-WT-16 Y FD-1 drains along roadways and drains |
| North Paguate Area: | N2 at east end of drain system |
| | Area S, T, N at transitions between piles on slopes, drains |
| South Paguate Area | SP-WS-20, SP-WT-19 along slopes and drainage areas |
| | SP-WS-17, SP-WS-13A at drainage area |
| | SP-WS-07 at drainage area |
| | Q, R, Main Access Road slopes and drainage areas |

**Conclusions** - OAS considers the non-use of dumps H and J (as backfill) to be a non-substantive variance from the ROD requirements, given that the features were otherwise closed in accordance with specified procedures. Issuance of Construction Specifications with alternate cover requirements from the ROD, implies an acceptance of those new depths by the relevant parties. However, the berming design that was implemented for the reclamation did not perform as expected. The areas of chronic erosion blow-outs will be considered non-compliant if radioactive material is exposed or RAD levels exceed the specified limits.

**Recommendations** - An evaluation of the chronic blowout areas, to determine if solutions can be designed to relieve these continuing maintenance problems, is recommended. Erosion should be monitored with appropriate equipment to determine if radiological safety is a concern. If the underlying material is non-RAD emitting, the slopes may be allowed to erode naturally.

*e.* ***Additional surface treatment is outlined under "Revegetation Methods" below. Detailed modifications and treatments are presented in Table I-4 of the FEIS.***

Revegetation will be discussed in detail in Section 9 - Revegetation Methods.

## 4. *PROTORE STOCKPILES*

***All protore will be used as backfill material in pit areas. Backfill will be covered with 3 feet of overburden and 2 feet of Tres Hermanos Sandstone or alluvial material.***

As discussed in section 3c, the cover depths for the protore were revised by the construction specifications. The cover requirement for protore was established in the specifications, as a 1.0-foot radon cover and 2.0 feet of soil.

Protore was moved under Work Units 2E1N into the North Paguate Pit between December 1989 through closeout in April 1991 (Appendix A, Tables A-3 and A-4).

The quantities for these movements are listed in Project Status Report No. 20, March 1991, attachment.

Protore was moved under Work Unit 2E1S02 into the South Paguate Pit between April and May 1991 (Tables A-3 and A-4). The quantities for these movements are listed in Project Status Report No. 26, September 1991, attachment.

Protore was moved under Work Units 2E1J into the Jackpile Pit between May 1991 through closeout in April 1993 (Tables A-3 and A-4). The quantities for these movements are listed in Project Status Report No. 43, February 1993, attachment.

There are field records available where remediation technicians verified cover depths of shale placed on protore areas and depths of top soil on a variety of areas. These are found in the Library under "Shale Cover" and "Top Soil", respectively. Probes were used and depths recorded on 100-foot by 100-foot grids. In some cases gamma survey results after placement of shale, were also available. Those data are summarized in Tables 3 and 4 above in section 3c.

**Conclusions** - While the letter of the ROD was not met, the revised shale barrier depth was met in all cases tested. The top soil cover was less than the revised 24 inches, but in all cases it was at least 18 inches. The gamma concentration, after placement of the cover, was below the criteria of twice background levels.

**Recommendations** - Although the covers did not meet the ROD or the reclamation specifications, the covers appear to be adequate for radiation safety concerns. No further action is recommended.

## 5. *SITE STABILITY AND DRAINAGE*

### A. *Stream Stability:*

1. ***All contaminated soils and fill material within 100 feet of the Rio Paguate west of its confluence with the Rio Moquino, will be excavated and relocated to the open pits.***

There were numerous piles along the Rio Paguate. The following charts their movement based on work units:

**Table 6**
**Movement of Contaminated Soils and Fill Material**

| Work Unit | Area Moved to North Paguate Pit | Date Closed |
|---|---|---|
| 2E1N04 | Move Protore 2E | Feb-90 |
| 2E1N05 | Move Protore 10,SP-2-D, SP-1-C | Nov-90 |
| 2E1N06 | Move Protore 10,SP-2-D, SP-1-C | Nov-90 |
| 2E1N07 | Move Protore SP-1-A | Nov-90 |
| 2E1N11 | Move Protore SP-1 | Feb-90 |
| 2E4N01 | Contaminated Soils | Sep-91 |
| 2E4N01 A | North Rio Paguate East | Dec-91 |
| 2E4N01 B | North Rio Paguate West | Dec-91 |

Photo B-14, Appendix B, shows the area along the Rio Paguate where the piles once were.

**Conclusions** - The reclamation actions appear to have been compliant with this item of the ROD.

**Recommendations** – No further activities are recommended.

2. ***For the Rio Moquino, waste dumps S, T, U, N, and N2 will be pulled back 50 feet from the centerline of the stream channel. The toes of these dumps will be armored with rip-rap.***

A memorandum dated April 23, 1991 from J.H Olsen, Jr. to Governor Harry Early (*"Pueblo of Laguna Council, Reclamation Project Issues", April 23, 1991)* documented POL Council approved design changes and recommended forwarding descriptions of changes to the BIA for approval. A signed copy of the approvals and authorizations was not found. One of the changes was to revise the approach for erosion control along the Rio Moquino. The following is the relevant excerpt from that memorandum (pg. 1, ¶ 3).

*"SPECIAL CASE DESIGN NO. 1-RIO MOQUINO: This case involves removing any potentially contaminated material within the Rio Moquino area which could erode downstream. It eliminates the need for the re-channelization and heavy erosion control structures in the first design. A bench will be excavated on the west side dump and appropriate erosion controls will be placed as needed. Hydraulic analysis on the existing channel was performed by Weston Engineering as a basis for determining the action taken. Estimated cost is now $1,400,000 compared to the $1,900,000 in the Jacob's estimate."*

The following work units cover the movement of the waste and protore piles along the Rio Moquino above the confluence and the Rio Moquino Erosion Control activities:

**Table 7**
**Movement of Waste and Protore Piles Along the Rio Moquino**

| Work Unit | Area Moved to North Paguate Pit | Date Closed |
|---|---|---|
| 2E1N02 | Move Protore SP-2C | Sep 91 |
| 2E1N03 | Move Protore 1 B | Nov-90 |
| 2E1N010 | Move Waste Pile N | Sep 91 |
| 2E6N01 A | Pull Back Contaminated Soil Along Rio Paguate | Nov 94 |

Photos B-15, 16, and 17, Appendix B, show an archived POL photo from approximately 1994 and two 2006 photos of the Erosion Control along the Rio Moquino.

**Conclusions** - The material appears to have been relocated or pulled back and armored to the specifications of the ROD and the approved changes. The Landmark/Weston Design, (Landmark Reclamation/Weston, "*Jackpile Reclamation Project, Pueblo of Laguna, New Mexico, Draft Special Case Designs*", December 1990) with the approved changes, reduced the rigor of the original erosion protection. The approved design was implemented and the letter of the ROD was met. However, the intent of the ROD is not being met because the design was inadequate to prevent erosion of the banks below the toes of the waste piles.

However, significant erosion has taken place in the past 12 years. If erosion continues at the same rate, there is serious potential for exposure of waste or contaminated soil at the toes of Piles S, T, U, N, and N2. In view of the fact that a less rigorous redesign was approved after the ROD, this unexpected erosion is a problem. If the erosion continues, waste material will be exposed creating the potential risk of human and wildlife exposure to unknown hazards, and a threat to the water quality of the Rio Moquino.

**Recommendations** - A more thorough inspection and hydraulic analysis and erosion study needs to be performed to determine if additional erosion protection is needed along the Rio Moquino above the confluence. A control structure on the Rio Moquino above the Pueblo of Laguna section may also be considered.

3. ***A concrete drop structure will be constructed across the Rio Moquino approximately 400 feet above the confluence with the Rio Paguate.***

There was a six-foot drop at the main Jackpile haul road crossing of the Rio Moquino. A control structure was planned and included in the ROD. A flood occurred in July 1993 and is documented in Project Status Report No. 48, July 1993. There were no photos of the roadway crossing washout presented in that monthly report. The local USGS gauging station was washed out with the flood so the precise size of the storm was not recorded. It is estimated to have been greater than a 100-year flood. The flood washed out the crossing and the route was abandoned. This is documented in Project Status Report No. 48. The access route to the Jackpile site was re-routed to a low water crossing southwest of the Jackpile, which is currently used. Since the old crossing is no longer used there is no need to place a drop structure.

Photo B-18, Appendix B, is a 2006 OAS photo of the Rio Moquino at the former road crossing. Aerial photographs were reviewed pre flooding (1992) and post flooding (1993), however, the solution was insufficient to illuminate that area.

**Conclusions** - Due to the flash flood event that caused the stream crossing to be relocated and changed the stream flow conditions, the Rio Moquino drop structure was no longer needed. Therefore, compliance with this ROD requirement is not applicable.

**Recommendations** – No further activities are recommended.

**B. *Arroyo Headcutting:***

***Arroyos south of waste dumps I, Y, and Y2, and the arroyo west of waste dumps FD-1 and FD-3 will be armored as shown in the FEIS Appendix A (Figure A-13). Other headcuts encountered during reclamation will also be stabilized by armoring.***

The arroyo headcutting west of the waste dumps ended when the sandstone outcropping was encountered at the surface. It was determined that armoring was not needed to prevent further headcutting. An OAS 2006 Photo B-19, Appendix B, shows the sandstone outcropping. There has been no appreciable headcutting in the area since the outcrop became exposed. Headcutting areas are shown on the Base Map.

**Conclusions** - Based on OAS field inspection documented in the photograph, field conditions changed when the headcutting encountered a natural outcropping of sandstone. The sandstone impedes further headcutting negating the need for armoring. Therefore, this is considered a non-substantive variance from the ROD requirements.

**Recommendations** – No further activities are recommended at this time.

**C. *Blocked Drainages:***

1. ***Waste dump J and protore stockpiles SP-17BC and SP-6-B will be removed to unblock ephemeral drainage on the south side of the mine site.***

Blocked drainages are shown on Exhibits 1 and 2.

Waste dump J was found to not be blocking the stream. Distance made it uneconomical to transport the waste into the Jackpile pit, therefore, it was not removed. It was sloped, covered and seeded.

Protore Pile SP-6-B move is documented in Project Status Report No. 43, February 1992. However, SP 17BC was not mentioned in the Jackpile Protore report attached to Project Status Report No. 43. An aerial photo dated 8-21-03 indicates that material has been removed from both those protore areas and revegetation is taking place. This can be seen in the areas just to the east of the remaining waste dump J. The aerial photo also supports the statement that waste dump J does NOT block any drainage.

Photo B-20, Appendix B, shows waste dump J in the background and the level ground in the front formerly contained the protore piles SP-6B and SP-17BC.

**Conclusions** - While the letter of the ROD was not met with regard to the movement of waste dump J, closing it in place appears to meet the intent of the ROD and no problems have arisen to date by this action. However, this area could be a physical hazard in that livestock could become entangled in the submerged fence, or stuck in the mud.

**Recommendations** – Because the land grant property is in close proximity to the Pueblo of Laguna, an effort should be made to jointly maintain the existing dirt banks and monitor the ponded water to determine if it presents any chemical or radiological hazard for domestic animals or wildlife. After the evaluation has been completed, a long-term solution may be devised.

2. ***Two blocked drainages north of FD-I and F dumps will remain blocked. The remainder of the minesite, excluding open pits, will drain to Rios Paguate and Moquino.***

The blockages to the north of FD-1 and F were left and subsequently a semi-permanent ponded area has formed north of the Jackpile Pit. An OAS 2006 photo B-21, Appendix B shows the large ponded area.

M. Sarracino reports the pond stretches onto the Trust Lands to the north. Cattle from these lands have watered at this pond and several have drowned, leading to damage claims against the tribe.

There are no other ponded areas outside the pit on the Indian lands, so the remaining areas appear to be draining to the Rio Paguate and Rio Moquino, as planned.

**Conclusions** - The letter of the ROD has been met. However, an unforeseen circumstance has arisen in that the ponded water appears to be at least a physical hazard, and potentially a chemical and radiation hazard, for the neighboring landowners and the cattle that are grazed on that land.

**Recommendations** - Since grazing livestock have access to the ponded water, POL should sample the water to determine if it presents any chemical or radiological threat to the grazing animals. Additionally, the pond has been in the past, a physical hazard for the domestic animals. The area needs to be evaluated and a long-term solution devised.

## 6. *SURFACE FACILITIES/STRUCTURES*

### A. *Lease No. 1:*

***All buildings on Lease No. 1 (Jackpile lease) will be demolished and removed except for the Geology building, miner training center and buildings at the old shop and the open pit offices. The land surface (except pit highwalls and natural outcrops) will be cleared of radiological material (e.g., Jackpile Sandstone) until gamma readings of twice background, or less, are achieved. These areas will then be graded and seeded.***

Site inspection indicated all structures were removed and the areas appear to be re-vegetated successfully. Although the ROD noted that some structures were to remain at the site, deterioration and safety issues required dismantling of these structures.

Radiological Clearance is discussed in Section 10-Monitoring of this report.

**Table 8**
**Lease No. 1 - Facilities/Structures Status**

| Jackpile Lease No. 1 | Proposed | Status |
|---|---|---|
| Geology Building at Housing Area | Leave in Place | Deterioration and Safety Issues required dismantling. Panels stored at LCC shop area |
| Miner Training Center at Housing Area | Leave in Place | Deterioration and Safety Issues required dismantling. |
| Old Shop Buildings across Highway | Leave in Place | Deterioration and Safety Issues required dismantling. |
| Open Pit Offices | Leave in Place | Asbestos and Safety Issues required dismantling. |
| All other buildings | Demolish | Deterioration and Safety Issues required dismantling. |

The information in the Status column above was provided to OAS by M. Sarracino, January 30, 2007. He further stated that all areas were disked and seeded. Some of this can be substantiated in the memorandum, dated April 23, 1991 from POL Project Manager J.H. Olsen. Jr. to Governor Harry Early recommending approval by the council of Special Cases. (*"Pueblo of Laguna Council, Reclamation Project Issues", April 23, 1991)*

**B.** ***Lease No. 4:***

***All structures and facilities associated with the P-10 mine and new shop, including all buildings, roads, parking lots, sewage systems, power lines and poles, will be left in place. All operational and maintenance equipment, including tools, machinery, and supplies will be removed. All permanent structures and land surfaces (except pit highwalls and natural outcrops) will be cleared of radiological material until gamma readings of twice background or less are achieved. These areas will then be graded and seeded. Non-salvageable contaminated buildings and materials will be removed to the pits for disposal.***

A memorandum dated April 23, 1991 from J.H Olsen, Jr. to Governor Harry Early (*"Pueblo of Laguna Council, Reclamation Project Issues", April 23, 1991)* documented POL Council approved design changes and recommended forwarding descriptions of changes to the BIA for approval. A signed copy of the approvals and authorizations was not found. Some of the changes related to deviations from facilities demolition plan. The following is the relevant excerpt from that memorandum. (pg. 4, ¶ 1)

*" d) REMOVAL OF REMAINING BUILDINGS*

*Two buildings at the P-10 site need to be dismantled so the required backfill and site cleanup around the decline can be completed. The old welding shop also needs to be dismantled since the sheet metal panels are deteriorating and becoming a potential hazard. The old Geology Building and the P-10 compressor building have already been dismantled and the materials stored in the LCC Shop Yard. Unless other direction is received by May 31, 1991, the buildings will be dismantled by the LCC Surface Crew and the materials placed in the LCC Shop Yard for future use. Prior to release of these materials, however, a radiological survey would need to be performed by Eberline in accordance with the Environmental Monitoring requirements."*

Site inspection indicated all structures were removed and the areas appear to be re-vegetated successfully.

**Table 9**
**Lease No. 4 – Facilities/Structures Status**

| P-10 Lease No. 4 | Proposed | Status |
|---|---|---|
| Buildings | Leave in Place | Deterioration and Safety Issues required dismantling. |
| Roads | Leave in Place | Left in Place |
| Parking Lots | Leave in Place | Abandoned, graded and seeded |
| Sewage Systems | Leave in Place | Abandoned Pond, graded and seeded |
| Power lines & Poles | Leave in Place | Dismantled due to aesthetics and safety issues |

Information presented in the Status column above was provided to OAS by M. Sarracino, January 30, 2007. He further stated that all areas were disked and seeded. Some of this can be substantiated in the memorandum, dated April 23, 1991 from POL Project Manager J.H. Olsen, Jr. to Governor Harry Early recommending approval by the council of Special Case Designs. (*"Pueblo of Laguna Council, Reclamation Project Issues", April 23, 1991)*

**Table 10**
**New Shops – Facilities/Structures Status**

| New Shops | Proposed | Status |
|---|---|---|
| Buildings | Leave in Place | Left in Place, Active |
| Roads | Leave in Place | Left in Place, Active |
| Parking Lots | Leave in Place | Left in Place, Active |
| Sewage Systems | Leave in Place | Left in Place, Active |
| Power lines & Poles | Leave in Place | Left in Place, Active |

## C. *Access Routes:*

***The four major roads within the mine site will be cleared of radiological material and left after reclamation for post mining use. These access routes include: 1) the access road from P-10 and the new shop area to State Highway 279; 2) the main road through the mine; 3) the road that passes between the housing area and North Oak Canyon Mesa and then proceeds to P-10; and, 4) road to Jackpile well No. 4. All other roads (except on lease No. 4) will be removed. These areas will then be graded and seeded.***

Site inspection revealed the following status of the roadways covered by the ROD. Exhibits 1 and 2 show the locations of these routes.

**Table 11**
**Access Routes Status**

| Roads | Proposed | Status |
|---|---|---|
| P10 & New Shops to Hwy 279 | Leave in Place | Active, maintained dirt road |
| Main Road Through Mine | Leave in Place | Active, maintained dirt road |
| Housing and Oak Canyon to P-10, | Leave in Place | Abandoned, other access way |
| Road to Jackpile well No.4 | Leave in Place | Active, maintained dirt road |
| All others except Lease No. 4 | Grade & Seed | Abandoned, no maintenance, no grading or seeding. |

The information in the *Status* column above was provided to OAS by M. Sarracino, on January 30, 2007. Photos B-22 and B-23, Appendix B, respectively show the P-10 Well features and the New Shop Well features.

**D.** *Water Wells:*

***Jackpile well No. 4, the P-10 well, the new shop well, the old shop well, and the 3 wells with associated sheltering structures (near the housing area) will be left. The pumps, riser pipe, wiring, and water storage tanks will be removed. Wells established for future monitoring purposes will also be left. All wells will be capped to prevent dust, soil, and other contaminants from entering the well casing.***

**Table 12**
**Water Wells Status**

| Water Supply | Well Pipe | Pump | Riser | Wiring | Tanks |
|---|---|---|---|---|---|
| Jackpile No.4 | capped | removed | removed | removed | removed |
| P-10 | capped | removed | remains | remains | remains |
| New Shop | active | active | active | active | active |
| Housing area (3 wells) | closed | removed | removed | removed | removed |

E. *Rail Spur:*

***The rail spur will be left intact. The rail spur must be cleared of radiological material until gamma readings of twice background or less are achieved. The Quirk loading dock will be demolished and hauled to the pits.***

Based on OAS site inspections, the Quirk Loading Dock was demolished and the rail spur remains.

**Conclusions** - Based on memoranda, discussions with M. Sarracino and an OAS field inspection, some features shown which were anticipated to be kept or salvaged were found to be of very poor condition. While not in strict compliance with the ROD, the demolition and disposal of additional facilities in no way impairs the environmental integrity of the project. Therefore, this is considered a non-substantive variance from ROD requirements.

**Recommendations** – No further activities are recommended.

## 7. *DRILL HOLES*

***All drill holes will be plugged according to the State Engineer's requirements. A 5-foot surface concrete plug will also be placed in each hole. Any cased holes will have the casing cut off at the surface. In addition, areas around drill holes will be seeded. Any exploration roads not wanted by the Pueblo will be reclaimed.***

Project Status Report No. 4, November 1989, reports that Work Item 2S1S05 is to plug drill holes. However, the report states *"There is no work to be done in this package. The CMC inspector has gone over the entire area where the drill holes were, and did not find a single one open."*

**Conclusions** - It is unclear what happened to the drill holes. No drill holes were found by CSM and that work unit was closed out on approval of all three parties. Therefore, this is considered a non-substantive variance from the ROD requirements.

**Recommendations** – No further activities are recommended at this time.

## 8. *UNDERGROUND MODIFICATIONS*

### A. *Ventilation Holes:*

***Vent holes will be backfilled with waste material (Dakota Sandstone and Mancos shale) to within six feet of surface. Surface casing will be removed, steel support pins installed in walls of vent holes, and sealed with a six-foot concrete plug from backfill to surface. Areas around vent holes will be contoured and seeded.***

Project Status Report No. 2, September 1989 reports ongoing activity with respect to locating vent holes. Project Status Report No. 4, November 1989 reports all the vent holes have been closed under Work Unit 2S1S04 except for one in the Jackpile Pit. Project Status Report No. 32, March 1992 indicates the closeout of Work Unit 2S1S04, therefore, it is assumed that the Jackpile vent hole was closed. There are no specifics with regard to the actual physical closures methods used on the vent holes.

**Conclusions** - It is unclear how the vent holes were closed and there are no records of how they were closed. Monthly reports indicated that the vent holes were being closed, and the work unit was closed out on approval of all three parties. Therefore, this is considered in compliance with the ROD requirements.

**Recommendations** – No further activities are recommended at this time.

## B. *Adits and Declines:*

***A concrete bulkhead will be constructed approximately 680 feet below the portal of P-10 decline. The decline will be backfilled from bulkhead to ground surface with Dakota Sandstone and Mancos shale. Sufficient material will be placed over the portal to allow for compaction and settling. The ground surface above the buried portal will be sloped and then top-dressed and seeded. The Alpine mine entry will be bulkheaded and backfilled. Mine entries not previously plugged by backfilling will be covered. Additionally, the H-1 mine adits will be bulkheaded and backfilled and the adits at the P-13 and NJ-45 mines will be backfilled.***

Exhibits 1 and 2 present the locations of these mine features.

Although the details of the closures are unknown, the closures appear to have been successful. The general site inspection of areas of the former underground features revealed no evidence of underground mining accesses, no evidence of subsidence, and in general, the areas were indistinguishable from surrounding areas, indicating successful revegetation. The following table summarizes the various entrances and the relevant work unit and closure date when available.

**Table 13**
**Adits and Declines Status**

| ADITS | Status / Closure Means | Work Unit and Progress Status Reports | Closure Date |
|---|---|---|---|
| **P-10** | Bulkheaded and Backfilled, Checked for subsidence | 2S1S02<br>Redesign – Project Status Report No. 16<br>Activity – Project Status Reports No. 30 & 31 | March 1992 |
| **Alpine** | Backfilled and Checked for subsidence | No Specific Work Unit | --- |
| **H-1** | Backfilled and Checked for subsidence | 2S1S03<br>Closure – Project Status Report No. 28 | November 1990 |
| **P-13** | Backfilled and Checked for subsidence | 2S1S01<br>Closure – Project Status Report No. 29 | December 1991 |

| ADITS | Status / Closure Means | Work Unit and Progress Status Reports | Closure Date |
|---|---|---|---|
| **NJ-45** | Backfilled and Checked for subsidence | No Specific Work Unit | --- |
| ***P 2/3 Adit*** | Backfilled and Checked for subsidence | 2S1N01 | March 1990 |

The information in the Status column above was provided to OAS by M. Sarracino, January 30, 2007.

Correspondence from the BIA to Governor Lucero, dated December 20, 1990, contains as an attachment a redesign proposed by Landmark Reclamation entitled "Report of Investigation of P-10 Design". Based on the content of the correspondence and attached memorandum, it appears that the new design was adopted by the project team (US Department of the Interior, Bureau of Indian Affairs, Correspondence to Governor Conrad W. Lucero, with attachments including Landmark Reclamation, *"Report of Investigation of the P-10 Decline – Jackpile Project"* (dtd July 30, 1990), December 20, 1990).

**Conclusions** - It is unclear how the mine entries were closed. But the work units were closed out on approval of all three parties. Because all three parties approved an alternate closure method, it is presumed that the intent of the ROD was met. However, the potential for subsidence may still exist.

**Recommendations** - Continue to monitor the P-10 and P 2/3 areas for subsidence. Closure methods apparently presented some potential for a "controlled accident", as was stated in the Landmark Reclamation report referenced above.

## 9. *REVEGETATION METHODS*

### A. *Top Dressing:*

***Following final sloping and grading, pit bottoms will be top dressed with 24 inches, waste dumps with 18 inches, and all other areas within the minesite with 12 inches of material composed primarily of Tres Hermanos Sandstone (stockpiles at three locations within the minesite). In order to meet top dressing volume requirements for the northern portion of the minesite, additional material may be obtained from a topsoil borrow area in the Rio Moquino floodplain comprising 44 acres. For the southern portion of the minesite, additional topsoil borrow material located east of J and H dumps may be needed. Following topsoil removal, disturbed borrow areas will be contoured, fertilized, seeded, and mulched.***

Exhibit 2 shows the topsoil pile locations. Section 3 discusses the waste dumps and their sloping, contouring and cover depths. Verification of top soil depths is also presented in Section 3, Table 4.

**B. *Surface Preparation:***

***After applying top dressing, areas to be planted will be fertilized, followed by disking to a depth of 8 inches and then contour furrowing.***

A memorandum dated April 23, 1991 from J.H Olsen, Jr. to Governor Harry Early (*"Pueblo of Laguna Council, Reclamation Project Issues", April 23, 1991)* documented POL Council approved design changes and recommended forwarding descriptions of changes to the BIA for approval. A signed copy of the approvals and authorizations was not found. One of the changes was to revise the approach for top dressing and revegetation. The following is the relevant excerpt from that memorandum. (pg. 3, ¶ 1)

*"TOP DRESSING AND REVEGETATION SPECIFICATIONS: This section specifies the disking, soil placement, seeding, mulching and crimping operations to be used. Following soil placement, the areas will be left fallow until after the typical rainy season so moisture can be re-established in the seedbed. A schedule of activities and the "time window" available to perform them was developed to help the construction activities be coordinated to take advantage of these aspects. Seed mixtures, application rates, and estimated costs are also included. Seeds types to be used include grama grasses, fourwing saltbush, sweetclover, Indian ricegrass, bluestem, sacaton, and others are recommended. Discing will be done to help bind the shale to the topsoil cover. Disking at 45 degrees to the slope will enhance this binding capacity. Seeding will be done with hydroseeding equipment but use of seed drilling equipment on the flat areas is optional and acceptable. Final crimping of mulch and cross-discing on opposing 45 to 60-degree passes on the final slope are also done to help control minor rilling and the formation of water pathways down the slopes. Monitoring procedures are included. An optional specification for tree planting (recommended species and planting procedures) was developed should the POL wish to utilize this technique. Work Packages for the estimated cost can be included in future Annual Operating Plans for Council consideration/action."*

**C. *Seeding and Seed Mixtures:***

***Before seeding operations begin, the entire minesite will be fenced to prevent livestock grazing. In most situations, seed mixtures will be planted with a rangeland drill. Broadcast seeding combined with hydromulching may be used on inaccessible sites or if determined to be more feasible than drilling. For both methods, the seed mixture will consist mainly of native plant species possessing qualities compatible with post grazing use and adapted to the local environment (Tables 3-10 and 3-11; FEIS). Following drill seeding, straw***

***mulch will be applied at about 2 tons per acre, and crimped into place with a notched disk.***

There is some seed preparation and seeding that is documented in the "*Jackpile Project Final Design Recommendations for BIA Approval*", May 9, 1990. (pg. 1, ¶ 1 & 5):

> *"1) Previously-reclaimed areas will be left in their current condition except where minor remedial work will be required to repair small rills or gullies. Re-seeding of bare spots on slopes will be done using "hydro-seeding" and mulching techniques. Any remedial work will be done so as to minimize any adverse impact on existing vegetation or other stabilizing features. Re-aligning of drainage paths will be done.*
>
> *5) Hydroseeding is the preferred method since recent reclamation experience on 3:1 slopes shows that use of seed drills and equipment to crimp the mulch actually cause more erosive pathways. Page 7 of the ROD allows for a more "feasible" technique than seed drilling, if available."*

**D.** ***Revegetation Success:***

***Using the Community Structure Analysis (CSA) or comparable method, plant establishment will be considered successful when revegetated sites reach 90 percent of the density, frequency, foliar cover, basal cover, and production of undisturbed reference areas (but not sooner than 10 years following seeding). Livestock grazing will be prevented until 90 percent comparability values are met. At the end of the 10-year monitoring period, if an unsuccessful trend is shown, retreatment may be necessary to achieve success criteria. In the pit bottoms, vegetation will be sampled annually for radionuclides and heavy metal uptake.***

As the Jacobs Environmental Monitoring Plan states, revegetation of the site is a critical requirement for stabilizing the disturbed area against erosion and returning the site to productive use. It designated short term monitoring to determine that seeds have germinated and seedlings are growing appropriately and so that corrective measures can be taken to assure success and long term monitoring to meet the ROD. There are references to visual vegetation inspections by "*Ed Kelley, Ph.D. (revegetation consultant)*" in Project Status Reports (Reports No. 43, Feb 1993 and No. 51, October 1993). The ROD requirements are to compare waste pile and pit bottom revegetation against reference sites and to cease monitoring after the revegetated areas meet 90% of the reference site (for selected parameters) but no sooner than 10 years. Four studies were performed:

1) October 1990 (Landmark/Weston 1991) - Landmark Reclamation/Weston, *"Jackpile Reclamation Project, Pueblo of Laguna, New Mexico, Soils and Vegetation Evaluation for Final Reclamation"*, Final, April 1991.
2) September/October 1996 (Munk and Boden 1996) - Munk, Lewis P. and Boden, Paul, Soils and Biogeochemistry, *"Interim Reclamation Success Analysis, North and South Paguate Open Pits, Jackpile-Paguate Uranium Mine"*, December 1996
3) USDA Natural Resources Conservation Service, 1998 Paguate-Jackpile Mine 1998 Vegetative Inventory [Production Surveys], 1998
4) USDA, Natural Resources Conservation Service, Vegetation Inventory, Production Surveys, August 16, 2000.
5) OA Systems Corporation, *Jackpile-Paguate Uranium Mine Record of Decision Compliance Assessment*, 2007

**Table 14**
**Revegetation Success Sampling Requirements Comparison**

| | EIS Table 1-5 | ROD | Jacobs Environmental Monitoring Plan | Actual |
|---|---|---|---|---|
| **Sampling Points** | Transects on waste dumps, pit bottoms and off-site reference areas | Items 9D and 12. Same as EIS | Same as ROD & EIS | 1) Early reclaimed mined areas and ref sites (Landmark/Weston 1991) 2) NP and SP pit areas and two reference areas (Munk and Boden 1996) 3) Pit Bottoms only, reference areas not used (NRCS 1998, 2000, 2006) |
| **Frequency** | Annually | | | 1) Once in 1990 during reclamation 2) Once in 1996 within NP and SP only, three years after seeding. 3) Three times after reclamation completion |

| | EIS Table 1-5 | ROD | Jacobs Environmental Monitoring Plan | Actual |
|---|---|---|---|---|
| **Parameters** | Density, Frequency, foliar cover, basal cover, and Production | | | 1) All ROD Parameters 2) All ROD Parameters 3) Production Sampling, plus qualitative (wind erosion, water erosion, soil crust, plant vigor, seedlings and seed reproduction) plus qualitative assessment of rangeland health using NRCS rating categories. |
| **Duration** | CSA = 90% but no sooner than 10 years following reclamation | | | No regular sampling or duration. The 90% target is not being achieved. |

The earlier vegetation studies by Landmark/Weston (1991) and Munk and Boden (1996) followed the procedures and parameter tests laid out by the ROD, but were conducted during and at the end of reclamation and not in the post closure period. During this prolonged study period (1989 through 2006), reference sites and their use as comparisons for successful revegetation evaluations were replaced by other methods. This is reflected in the 1996 Study ( Munk and Boden) where they stated that *"the use of reference areas as a reclamation standard is complicated by the lack of a model reference with ideal site characteristics"* and that *"that the reclamation success is obscured by these simple single parameter statistical comparison because of the differences in the vegetative composition among the reclaimed and reference areas."* In subsequent studies conducted by the NRCS and Cedar Creek other evaluation criteria evolved, as discussed below.

**<u>Discussion</u>** - The three monitoring reports in 1991, 1996, and 2006 consistently determined that vegetation on the reclaimed mine areas can be considered successful in meeting the primary goals of landscape stability, productivity, and good to excellent plant communities.

- The1991 Landmark/Weston report recommended that the vegetation criteria be developed based on acceptable values rather than specific reference sites. Using these criteria, *"All of the reclaimed sites except one (vegetation survey site V-4) could be released for post-reclamation land uses without further monitoring."*

- The 1996 Munk and Boden report stated that, *"In general, reclamation in the pit bottoms can be considered successful in meeting the goals of landscape stability, productivity, and containment of the protore."* The reclaimed areas did not meet the strict numerical standards of the ROD requirements, but had vigorous and productive plant communities with desirable perennial grasses and shrubs.
- In the 2006 monitoring report (Cedar Creek 2006), in addition to assessing cover and productivity, followed suggested protocol based on NRCS methods for evaluating and rating ecological sites for health and stability in Chapter 4 of the National Range and Pasture Handbook for inventorying and monitoring land resources. The sampling and monitoring results compared these naturalized plant communities (on the reclaimed mine site) to the desired plant community based on the reclamation and revegetation techniques (grading, topographic and water control, and seed mix) used on the Jackpile mine. The trends and ecological health of the plant communities, and other physical attributes, showed excellent balance and sustainability of the reclaimed areas for physical structure (topography, soils), hydrology (streams, runoff, watersheds, pools, springs and seeps), and ecology (vegetation, animals, and habitats).

The results of the vegetation monitoring show good to excellent plant communities with foliar cover values of 43-50%; according to Landmark/Weston (1991) regional values are 10.3% to 26.5%, so the cover values far exceed the 90% specified in the ROD; and plant production of 523-1,043 lbs/ac on the reclaimed lands. The trends in vegetation are stable for plant diversity and health. The reclaimed mine areas can be considered successfully revegetated based on the available monitoring data. The reclaimed mine has stable and self-sustaining diverse ecosystems with very good to excellent vegetative cover and productivity of desirable plant species, and good habitat for local wildlife. There are no comparable reference sites for determining the success standards of these ecosystems as required by the ROD. The conclusions of the monitoring reports were that the mine has successful vegetation based on production and other criteria of stability and sustainability.

**Conclusions** - The Jackpile Reclamation Project post reclamation vegetation monitoring program deviated from the requirement of the Record of Decisions. This was due to evolution in the methodologies developed, accepted and routinely accepted in the scientific community in determining vegetative success. The monitoring met the intent of the ROD in determining vegetation success, in that the mine was very successfully revegetated based on important vegetation parameters of cover and productivity. The revegetation did not meet the strict numerical standards of the ROD, but had vigorous and productive plant communities with desirable perennial grasses and shrubs. The condition of post-reclamation vegetation is very good to excellent, and the reclaimed mine has stable and self-sustaining diverse ecosystems, and good habitat for local wildlife. Trends in vegetation are stable for plant diversity and health.

Item 9-D of the ROD requires pit bottom vegetation be sampled annually for radiological and heavy metal uptake for a period of ten years. This was not done on a continuous basis during the 10-year period after reclamation was completed. Further discussion is presented in Section 10-Monitoring (f) and (g).

**Recommendations** - Vegetation uptake should continue to be monitored periodically in the future, especially in the pit bottoms. It has been suggested that monitoring be undertaken the next year and possibly every five years after next year; especially in the pit bottoms and in the North Paguate pit in particular.

## 10. *MONITORING*

***The monitoring period will vary for each parameter. Existing monitoring activities to be continued will include meteorologic sampling, air particulate sampling, radon sampling (ambient), radon exhalation sampling, gamma survey, soil and vegetation sampling, water monitoring, and subsidence. In addition, the monitoring program will be expanded to include: radon daughter levels (working levels) in any remaining mine buildings, and groundwater recovery levels/salt buildup in the open pits. The groundwater monitoring period will be of sufficient duration to determine the stable future water table conditions. Refer to Table I-5 of the FEIS for details of the monitoring plan as described under the Preferred Alternative.***

The Jacobs Environmental Monitoring Plan was developed for use during and after reclamation. This Environmental Monitoring Plan was approved October 1989 and implemented by the Pueblo of Laguna. To check for compliance with the ROD, OAS compared the Final EIS Table I-5 to both the Jacobs Environmental Monitoring Plan and the actual data sets provided by the POL.

It was stated in the introduction to the Jacobs Environmental Monitoring Plan that, *"as the Jackpile Project proceeded into the preparations of the final engineering designs and detailed project operating plans, modifications to the monitoring program were developed."* To view specific rationale for changes, the Jacobs Environmental Monitoring Plan should be reviewed. For the most part, the reasons included additional data obtained since the FEIS, technology advancements, closer review of existing data sets led to elimination of some monitoring as unnecessary, the decision to go with an independent party to collect and analyze the samples, and increased participation of the BIA in an oversight role. It is OAS' judgment that the reasons for modifying the FEIS lists appear to be reasonable and justified.

Many of the monitoring details were found in other documents and evolved over time. To address monitoring requirements, OAS broke the requirements out and addressed general areas of Water Quality, Soils and Plant Uptake, Vegetation Success and Radon. Since the data had not been organized, reviewed, QC checked or evaluated, OAS attempted to do this to some degree and has included individual reports in the Appendices of this document.

**a. Meteorologic**

The Jacobs Environmental Monitoring Report stated that the wind and precipitation data would be useful in determining when to conduct blasting operations, calculating radiation health impacts, determining irrigation needs in revegetation areas, and determining if operations should be stopped because of excessive dust.

There were some references to the purchase of a weather station in a Project Status Report and remnants of a weather station are near the old housing area. However, no data for weather monitoring was found.

**Table 15**
**Meteorologic Monitoring Requirements Comparison**

| | EIS Table 1-5 | ROD | Jacobs Environmental Monitoring Plan | Actual |
|---|---|---|---|---|
| **Sampling Points** | 3 | Item 10: Per EIS Table 1-5 | One Site Location near the center of the designated site. | No Records Found |
| **Frequency** | Continuously | | Continuously | |
| **Parameters** | Wind Speed and Direction | | Wind Speed & Direction, temperature, precipitation, | |
| **Duration** | A minimum of three years after reclamation | | During Reclamation and 3 years after | |

The lack of meteorological monitoring data represents **non-compliance** with the ROD. However, the lack of data has no real impact on post closure health and the environment risk, since the disturbed areas have revegetated well and there is no risk posed from blowing dust. Consequently, failure to comply with this requirement is probably not a significant variance.

**Conclusions** - Meteorologic monitoring was reportedly conducted during reclamation. There is, however, no data for monitoring conducted during that time. Meteorologic monitoring data was collected during reclamation as was appropriate. However, recurring data collection equipment problems resulted in discontinuous data collecting during the post-reclamation period. At least two different monitoring equipment suppliers were tried, but the power supply problems and problems with livestock destroying the equipment continued.

**Recommendations** – No further activities are recommended.

**b. Air Particulates**

Table 16 below presents the air particulates monitoring requirements as proposed in the EIS, ROD and Jacobs Environmental Monitoring Plan compared to the actual monitoring that was performed. The EIS proposed separate requirements for monitoring radiological and non-radiological particulates. The ROD and Jacobs requirements, and the actual monitoring that was performed, combined the radiological and non-radiological parameters as shown in the table. The table also shows the differences that were proposed in the number of sampling points and the duration of the monitoring.

**Table 16**
**Air Particulate Monitoring Requirements Comparison**

| | EIS Table 1-5 | ROD | Jacobs Environmental Monitoring Plan | Actual |
|---|---|---|---|---|
| **Sampling Points** | 4 | 5 | 5 | 5 |
| **Frequency** | Monthly | Monthly | Continuous | Continuous |
| **Parameters** | U (natural), Ra-226, Po-210, Th-230, Total Suspended Particulates (TSP) | U (natural), Ra-226, Po-210, Th-230, Total Suspended Particulates (TSP) | U (natural), Ra-226, Po-210, Th-230, Total Suspended Particulates (TSP) | U (natural), Ra-226, Po-210, Th-230, Total Suspended Particulates (TSP) |
| **Duration** | In perpetuity | During reclamation & a minimum of 3 years after | During construction until average levels ≤ 2 times background for 2 successive quarters; and after reclamation, one year & not more than 3 years | Requirement Phased-out |

In Section 3.3 of the Jacobs 1989 report, it was stated that "concentrations of uranium (U-238), thorium (Th-230) and radium (Ra-226) were routinely monitored during mining operations and the reported results were within the standards of the NRC (10 CFR Part 20)." Because the reclamation activities were expected to produce less dust than the mining operations, it was anticipated that the radioactive particle concentrations would be very low. During the reclamation operations the results of continuous sampling indicated levels of 0.5 of background to two times background for at least two successive quarters. As the cover was being placed, the levels gradually declined. When the reclamation was completed the levels were consistently at background levels or less than background. Based on those results, the BIA Contracting Officer (CO) and Pueblo of Laguna reportedly agreed to discontinue the particulate sampling as allowed for in Section 5.4 of the 1992 Post Reclamation Long-Term Monitoring Program "Phase-Out of Reporting Requirements". That section allows the requirement to be phased out if the BIA CO agrees that it has been adequately demonstrated that the goals and objectives of the monitoring function have been met.

**Conclusions** – The BIA Contracting Officer (CO) and Pueblo of Laguna reportedly agreed that it had been adequately demonstrated that the goals and objectives of the monitoring function had been met and agreed to discontinue the particulate sampling.

**Recommendations** – No further activities are recommended.

### c. Ambient Radon

The EIS requirement for monitoring of radon gas is compared to the ROD, Jacobs Environmental Monitoring Plan, and the actual monitoring that was performed, and is presented below in Table 17.

**Table 17**
**Radon Gas Monitoring Requirements Comparison**

| | EIS Table 1-5 | ROD | Jacobs Environmental Monitoring Plan | Actual |
|---|---|---|---|---|
| **Sampling Points** | 5 | Item 10: Per EIS Table 1-5 | 5 perimeter sites, including one between Paguate and the mine, 5 sites within the mine, 2 sites in Paguate, and 3 sites in onsite buildings. | Requirement was waived because measurements were consistently below the limit of 3.5 pCi/L set by the ROD |
| **Frequency** | Monthly | | Continuous after construction <3pCi/L for 4 quarters, 2 location in N.Paguate pits, 3 locations outside N.Paguate pits, 2 locations in S.Paguate pits, 4 locations outside S.Paguate pits, 2 locations in Jackpile pits, 4 locations outside Jackpile pits, and 2 location in Paguate | |
| **Parameters** | Rn-222(pCi/L) | | Rn-222(pCi/L) | |
| **Duration** | Minimum of 3 years after Reclamation | | 4 successive quarters no greater than 3pCi/L above background | |

The specified limit for radon gas levels after reclamation was 3 picocuries per liter (3 pCi/L) above the background level of 0.5 pCi/L, for a total limit of 3.5 pCi/L. Radon-222 gas was measured as suggested by the monitoring report (Jacobs 1989). The cups were set up on post three feet above ground at each location, and collected quarterly from April 1990 to May 1997. The monitoring station locations and time were recorded on Radon Test Detector log sheets or field forms, and the results listed on Radon Measurement Data sheets and Monitoring Reports for each quarterly testing period. The complete radon-222 survey results were tabulated and reported in the 1996 Annual Report for the Jackpile Reclamation Project. Measurements are reported in picocuries per liter (pCi/L).

**Conclusions** - All recorded radon gas measurements were consistently below the limit of 3.5 pCi/L set by the ROD. Because of the consistently low measurements it was mutually agreed to phase out this requirement.

**Recommendations** – No further activities are recommended.

**d. Radon Daughter Levels**

No records of radon daughter monitoring in remaining mine buildings was located. It is not expected, but if any of the remaining mine buildings have residual Uranium series contaminants (U, Ra 226) and the air in the buildings is relatively stale, monitoring is advised prior to extended occupancy.

**Conclusions** – No records of radon daughter level monitoring in remaining mine buildings were located. A radon daughter limit of 0.03WL working level was the specified threshold for this parameter. This is ***potentially non-compliant*** with the ROD. However, the buildings were reportedly razed at the start of reclamation. Therefore, compliance could not have been conducted or expected.

**Recommendations** – It is not expected, but if any of the remaining mine buildings have residual Uranium series contaminants (U, Ra 226) and the air in the buildings is relatively stale, monitoring is advised prior to extended occupancy.

**e. Radon Exhalation**

Radon Exhalation is the rate of Radon-222 emanation at the ground surface. It is a flux measurement of rate over a surface area. The Jacobs Monitoring Plan eliminated the requirement to measure radon flux *"due to difficulty and technical infeasibility of accurately measuring radon flux"*. The correlations of flux to doses of inhaled radon-22 are poor. There was never a flux standard established in the EIS or ROD to compare flux measurements.

**Table 18**
**Radon Exhalation Monitoring Requirements Comparison**

| | EIS Table 1-5 | ROD | Jacobs Environmental Monitoring Plan | Actual |
|---|---|---|---|---|
| **Sampling Points** | 5 | Item 10: Per EIS Table 1-5 | The monitoring of Radon-222 Flux was eliminated due to difficulty and technical feasibility of accurately measuring radon flux. The radon standard for the project was established as a concentration rather than a flux. | No Monitoring Performed |
| **Frequency** | Monthly | | | |
| **Parameters** | Rn-222 | | | |
| **Duration** | Minimum of 3 years after Reclamation | | | |

This monitoring requirement was eliminated by design at the time of monitoring program development, so while the letter of the ROD was not met, the elimination of this monitoring item was authorized when the monitoring program was adopted.

**Conclusions** - This monitoring requirement was eliminated by design at the time of monitoring program development, so while the letter of the ROD was not met, the elimination of this monitoring item was authorized when the monitoring program was adopted.

**Recommendations** – No further activities are recommended.

### f. Gamma Survey

Table 19 below presents the gamma radiation monitoring requirements as proposed in the EIS, ROD, Jacobs Environmental Monitoring Plans, and the actual monitoring that was performed.

**Table 19**
**Gamma Radiation Monitoring Requirements Comparison**

| | EIS Table 1-5 | ROD | Jacobs Environmental Monitoring Plan | Actual |
|---|---|---|---|---|
| **Sampling Points** | Each waste dump and selected reclaimed areas | Each waste dump and selected reclaimed areas | Each waste dump and selected reclaimed areas | Shops, construction buildings, offices, housing area, Paguate townsite, waste dumps & protore stockpile areas, crusher areas, haul and access roads, loading dock & rail spur from Quirk Station north to the project boundary, 3 pits (N.Paguate, S.Paguate & Jackpile during backfilling & covering with shale and topsoil. The final aerial survey was not conducted |
| **Frequency** | As Needed | As Needed | As Needed | |
| **Parameters** | Ground survey, plus final aerial survey | Ground survey, plus final aerial survey | Ground survey, plus final aerial survey | Ground survey. Final aerial survey not conducted |
| **Duration** | Before seeding and once after reclamation is completed | Before seeding and once after reclamation is completed | Before seeding and once after reclamation is completed | Ground survey. Final aerial survey not conducted |

The specified limit for gamma radiation levels after reclamation was twice the background level of 14 micro Roentgens per hour (μR/hr) for a total limit of 28 μR/hr.

Gamma radiation was measured using a TMA/Eberline gamma meter held three feet above the ground. The gamma surveys started during construction in 1990, and were concluded in 1993, when placement of the reclamation cover was completed. The required final aerial survey was not conducted. However, the ground survey that was conducted exceeded the requirement and it indicated no exceedance of the established threshold. There are no records of gamma radiation surveys after 1993. The following are the areas surveyed during the period of 1991 to 1993. They were selected based on recommendations from the EIS and monitoring reports.

1. Shops, construction buildings, and offices; housing area; Paguate townsite
2. Waste dumps and protore stockpile areas
3. Crusher areas; haul and access roads
4. Loading dock and rail spur from Quirk Station north to the project boundary (in 1990)
5. Three pits (North Paguate, South Paguate, and Jackpile) during backfilling and covering with shale and topsoil

Gamma radiation was measured using grids (100x100 feet or 200x100 feet) and recorded on field sheets, log and summary analytical sheets, and hand-drawn field maps. Measurements are recorded in micro Roentgens per hour (μR/hr).

Gamma radiation on the mine reclamation areas was reduced by moving protore and surfaces of the contaminated areas into the pits and covering them with shale and topsoil. Waste dumps that had Jackpile Sandstone on the surface were also covered with topsoil. These activities effectively reduced measured gamma radiation to acceptable levels of less than 25 μR/hr on the mine areas up to, and during, 1993. There were no records of post-reclamation monitoring of gamma radiation after completion of reclamation in 1996.

**Conclusions** – Based on this radiological measurement review, the following conclusions can be drawn:

1. Gamma radiation monitoring levels were consistently below the 28 μR/hr requirement, or lower, and a continuous monitoring program was not warranted.
2. The gamma radiation monitoring requirement stated that a ground survey, plus a final aerial survey, was to be conducted. The monitoring was to be conducted before seeding and after reclamation was completed. Monitoring was conducted before seeding, but the final aerial survey was not performed.

3. It is recommended that a final ground survey, or final aerial survey, be conducted, especially on the access roads, pit bottoms and former protore piles sites to verify that these areas meet the 28 μR/hr requirement.

**Recommendations** - Based on these conclusions, the following recommendations can be made:

1. Gamma radiation levels should be checked at least one more time to verify that reclaimed areas are meeting the standard of 28 μR/hr.
2. The reclaimed mine can be released from any requirement for radon gas measurements, and should present no hazards for human health.
3. The results of the process and sampling during the current and previous radiation monitoring should be reviewed.
4. Gamma radiation levels on the access roads, pit bottoms and former protore pile sites should be checked at least one more time, and in the future if the topography changes, to verify that those areas meet the 28 μR/hr requirement.

**g. Soil**

There were three types of soils testing discussed in documents associated with the Jackpile Reclamation: 1) testing for suitability for topsoil that could support revegetation goals, 2) testing of heavy metals and radiological compounds and 3) testing for salt buildup that could reach concentrations toxic to plants.

**Table 20**
**Soils Testing Requirements Comparison**

| | EIS Table 1-5 | ROD | Jacobs Environmental Monitoring Plan | Actual |
|---|---|---|---|---|
| **Sampling Points** | One grid per 50 acres on each waste dump and pit bottom | Item 10: EIS Table 1-5 Unspecific | For Salt Buildup<br>NP Pit: 2 east, 2 west<br>SP Pit: 2 east, 2 west<br>Jackpile: 4 locations<br>Half the locations in each pit will be in areas where ponding occurs after large precipitation events and half on well-drained areas.<br>Sample collected from 3 to 9 inches below surface.<br>Sampling points marked with 3 foot steel posts. | 1.) For Topsoil Suitability<br>Landmark/Weston (1991) collected 38 samples from 26 locations in the pit areas.<br>2.) For Potential for Plant Uptake<br>Munk & Boden (1997) collected 12 samples<br>3.) No Salinity Sampling |
| **Frequency** | Once Prior to Seeding | | Annually | 1.) Once<br>2.) Once |

| | | | | |
|---|---|---|---|---|
| **Parameters** | U(natural), RA-226, Th-230, Se, Va, As, Cd, Mo, Pb, Zn | | EC of saturated paste extract | 1.) pH, EC, saturation %, Ca, Mg, Na, SAR, soil characteristics<br>2.) As, Cu, Mo, Pb, Se, Zn, Va, Pb-210, Po-210, Ra-226 |
| **Duration** | Once Prior to Seeding | | Begin after backfilling and continue for 10 years | 1.) Once<br>2.) Once |

1) Topsoil. The Jacobs Monitoring Report discusses soil testing to determine suitability for topdressing which was part of the reclamation operations and included in the construction specifications. It was not a part of the Long Term Post Closure Monitoring Program discussed in ROD Item 10. There are several reports which contain data on soils for suitability for top dressing: Landmark/Weston (1991), Munk and Boden (1996) and Munk and Boden (1997) [Munk, Lewis P. and Boden, Paul, Soils and Biogeochemistry, "*Potential for Plant Uptake of Heavy Metals and Radionuclides, North and South Paguate Open Pits, Jackpile-Paguate Uranium Mine*", May 1997]. Appropriate topsoil source areas were found.

2) Radiologicals and Heavy Metals. The EIS Table 1-5 presents radiological and heavy metal parameters to be tested in soils from the dumps and pit bottoms, to assess potential for plant uptake. The Munk and Boden (1997) reports that samples were taken at 12 locations within the pits for some radiological and heavy metals compound. The analyses of the soil topdressing, shale cover material, and protore in the pit bottoms indicated that the heavy metals arsenic, copper, lead, molybdenum and zinc occurred at typical levels for natural soils. However, selenium, vanadium radium-226, Pb-210, Po-210 occurred at elevated levels in the Jackpile Sandstone protore. The exposed protore was considered the worst case scenario. All exposed protore within the pits were covered with the agreed upon barrier cover and topsoil depths and thus those elevated concentration should be of no concern. The ROD requirement for monitoring was met.

3) Salt Buildup. The ROD required salinity monitoring in the pits. The Jacobs Monitoring Plan directed the soils in the pits be monitored for salt buildup since a survey of drainages blocked by waste dumps showed the build-up of salts to levels toxic to plants in areas adjacent to the blockage. There were no data found regarding monitoring for salt in soils.

**Conclusions** – The topsoil, radiological and metals monitoring requirements of the ROD have been met. The salt buildup and impact to grazing has not been met.

**Recommendations** – The lack of salt monitoring represents ***non-compliance*** with the ROD requirements; however, the presence of well established vegetation would appear to indicate that salt buildup is not occurring. It is recommended that the pit bottom soils be analyzed for salt build up, and in the future if it appears that salt buildup is occurring.

### h. Radionuclide and Heavy Metal Uptake into Vegetation

The Jacobs Environmental Monitoring Report reports that early data sets showed that *"vegetation on the disturbed areas is not accumulating heavy metals or radionuclides in concentrations that are toxic to livestock"*, but that it would be prudent to monitor to see if uptake changed with time.

**Table 21**
**Monitoring Requirements for Radionuclide and Heavy Metal Uptake Into Vegetation Comparison**

| | EIS Table 1-5 | ROD | Jacobs Environmental Monitoring Plan | Actual |
|---|---|---|---|---|
| **Sampling Points** | Transects on selected reclaimed waste dumps and all pit bottoms | Item 12: EIS Table 1-5, minimum 10 years following reseeding | One location per dump with JSS on outer surface | Pit Bottoms |
| **Frequency** | Annually | | Annually | 2001,2003, 2005, 2006 |
| **Parameters** | U(natural), RA-226, Po-210, Th-230, Se, V, As, Cu, Cd, Mo, Pb, Zn | | Edible Fraction for Ra-226, Po-210, Pb-210, Se, Va, As, Mo, Pb, Cu, Zn | As, Cu, Pb, Mo, Se, V, Zn, Pb-210, Po-210, Ra-226 |
| **Duration** | A minimum of 10 years following reclamation | | Commence one year after reseeding for a minimum of 10 years following reclamation. Increase locations if the trends indicate that toxic levels are being approached. | |

The Jacobs Environmental Monitoring Plan presents justification for eliminating some of the compounds contained in the EIS Table 1-5. The report stated *"Thorium-230 does not present a significant ingestion pathway, Uranium has a low plant uptake factor, Pb-210 presents the greatest human exposure"*.

There were four years (2001, 2003, 2005, and 2006) in which vegetation was clipped and analyzed for heavy metals and radionuclides. The data are summarized in the Table 22 below.

**Table 22**
**Summary of Results of the Heavy Metal and Radionuclide Vegetation Uptake Monitoring for the Jackpile Reclamation Project**

| Year | 2001 – 15 Samples | | | 2003 – 10 Samples | | | 2005 – 39 Samples | | | 2006 – 16 Samples | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Range | ND * | Avg • | Range | ND | Avg • | Range | ND | Avg • | Range | ND | Avg • |
| **Metals** | | | | | | | | | | | | |
| As | 0-0.8 | 13 | 0.2 | - | 10 | - | 0-5.0 | 10 | 0.8 | 0-3.3 | 12 | 0.4 |
| Cu | 1.1-4.0 | 0 | 2.5 | 1.3-4.7 | 0 | 2.4 | 1.4-3.8 | 0 | 2.5 | 1.9-7.6 | 0 | 2.9 |
| Pb | 0-1.3 | 13 | 0.1 | 0-1.8 | 8 | 0.02 | 0-4.0 | 25 | 0.4 | 0-2.2 | 12 | 0.4 |
| Mo | 0-2.1 | 12 | 0.2 | 0-3.7 | 9 | 0.4 | 0-3.3 | 6 | 0.4 | 0-3.1 | 8 | 0.5 |
| Se | 0-9.4 | 9 | 1.5 | 0-5.3 | 3 | 0.9 | 0-5.3 | 9 | 1.4 | 0.5-42.9 | 0 | 6.4 |
| V | 0-3.7 | 9 | 0.6 | 0-4.8 | 7 | 0.6 | 0-8.1 | 28 | 0.7 | 0-19.1 | 13 | 1.5 |
| Zn | 9-47 | 0 | 20 | 8-29 | 0 | 15 | 3-34 | 0 | 18 | 8-25 | 0 | 14 |
| **Radionuclides** | | | | | | | | | | | | |
| $^{210}Pb$ | 0.1-0.9 | 0 | 0.44 | 0-1.12 | 1 | 0.50 | 0-0.3 | 14 | 0.07 | 0-.87 | 4 | 0.28 |
| $^{210}Po$ | 0-0.5 | 5 | 0.17 | .03-.34 | 0 | 0.12 | 0-0.2 | 2 | 0.05 | .02-1.16 | 0 | 0.28 |
| $^{226}Ra$ | 0-0.5 | 5 | 0.17 | 0.2-0.5 | 0 | 0.38 | 0-2.1 | 2 | 0.72 | .002-.51 | 1 | 0.19 |

*Results are in mg/Kg (ppm) for metals, and pCi/g (picocuries per gram) for radionuclides.*
**ND – number of samples below detection limits*

## Metals

Measured uptake concentrations of metals into vegetation were either below, or within, normal ranges for all heavy metals analyzed. As discussed by Munk and Boden (1997), the potential for uptake by most plants is minimal given the soil properties in the pit bottoms. This was confirmed by the four growing seasons (2001 to 2006) of vegetation sampled and analyzed for heavy metals. There was some concern by Munk and Boden (1997) that selenium and vanadium may accumulate on the surface soils and be translocated from the Jackpile Sandstone backfilled and covered in the pit bottoms. However, there was no increasing trend of these two metals measured in the vegetation eleven years after revegetation was complete.

The concentration in one shrub (four-wing saltbush) analyzed for selenium was within a normal high range, and may indicate that this shrub species is a secondary accumulator. This species is a member of the goosefoot family, and is not generally grazed by domestic livestock when other more palatable grass species are available.

Domestic livestock can graze the grass/shrub vegetation in the pit bottoms without toxic effects from heavy metals. Selenium was the only metal found to have the potential for sub acute toxicity on one sample in one shrub species that is generally not browsed by livestock. It is not recommended that heavy metals be monitored in the future based on the sample results to date.

**Radionuclides**

The concentration levels of radionuclides in the plant samples analyzed were uniformly low with no increasing trends in levels over the four seasons vegetation was sampled. The concentration levels are well below the values that are considered toxic to domestic livestock or wildlife; therefore, radionuclides would not need to be sampled in the future.

**Conclusions** - The Jackpile Reclamation Project vegetation uptake-monitoring program deviated from the requirement of the ROD in that heavy metals and radionuclides were not measured for ten consecutive years after reclamation was completed. Vegetation had low levels of metal and radionuclide uptake based on sampling and laboratory analysis. It is believed that vegetation growing on the reclaimed mine presents a minimal potential for hazards to domestic livestock or human health due to the low or normal concentrations of metals and radionuclides.

**Recommendations** - As previously mentioned in ROD Item 9, it has been recommended that uptake monitoring be undertaken next year and possibly on five-year intervals thereafter in the pit bottoms and particularly in the North Paguate pit.

**i. Water Quality**

OAS reviewed the post-reclamation water quality monitoring and data with the intention of: determining if the post-reclamation water quality monitoring has met the requirements of the ROD, examining the water quality data collected as to its validity and its applicability in assessing long-term risks to people and the environment, defining contaminants of concern and trends of these data, and making recommendations as to future monitoring programs and steps that should be taken to ensure the health and safety of nearby residents. This study is documented in the report "*Jackpile-Paguate Uranium Mine Post-Reclamation Water Quality Review*" presented in Appendix D.

- ***Sampling Points***

Table 23 presents the groundwater monitoring points. The FEIS proposed using 17 existing wells, the Jacobs Environmental Monitoring Plan proposed nine (9) groundwater well locations and formations for completion and six (6) wells to monitor the open pit groundwater, and two (2) or more wells at the discretion of the POL and BIA. According to the Jacobs Environmental Monitoring Plan, the existing wells were old, poorly constructed and documented, not located properly for assessment of long term monitoring of contaminant transport, so in effect unusable. Eight (8) wells were established in accordance with the Jacobs Environmental Monitoring Plan, one deep upgradient well collapsed and was abandoned early in the monitoring period. The two wells to be designated after the monitoring program was initiated were never placed. It is assumed that the 7-well coverage was deemed adequate by POL and BIA. Although the plan called for a downgradient well in the deeper Jackson Sandstone formation, both wells that are downgradient of the pits are completed in the Alluvium (MW-2 and MW-6). Four (4) of the six open pit wells were installed. No wells were installed in the Jackpile Pit. This oversight was corrected in 2007. None of the discretionary wells were installed.

**Table 23**
**Groundwater Monitoring Points**

| Final EIS Preferred Plan | Jacobs Environmental Monitoring Plan | | Actual | |
|---|---|---|---|---|
| **Well Location** | **Well Location** | **Formation for Completion** | **New Wells** | **Variation** |
| | **GROUP A** | | | |
| 17 existing wells (no specific locations indicated)<br><br>Old wells were not part of the reclamation monitoring program. These were deemed by Jacobs to be deteriorating, of unknown construction materials and configuration. | Southwest of South Paguate Pit (background well) | Jackpile Sandstone | MW-8 | This was a deep well that collapsed early in the monitoring program (JSS, Steel, 456 ft.) |
| | North of North Paguate Pit (background well) | Jackpile Sandstone | MW-1 | Upgradient of Paguate Pits (JSS, PVC, 231 ft.) |
| | North-northeast of Jackpile Pit (background well) | Jackpile Sandstone | MW-7 | Upgradient of Jackpile Pit (JSS, PVC, 375 ft.) |
| | North of the Rio Paguate and west of the Rio Moquino near the confluence | | | Not Installed |
| | South of the Rio Paguate and north of the South Paguate Pit | Alluvium | MW-4 | Between So. Pit and River (Alluvium, PVC, 50 ft.) |
| | South of the Jackpile Pit offices and east of the Rio Paguate | Alluvium | MW-3 | Between No. Pit and River (Alluvium, PVC, 60 ft.) |
| | In Oak Canyon adjacent to the designated site boundary | Jackpile Sandstone | MW-5 | Downgradient of South Paguate Pit (JSS, PVC, 262 ft.) |
| | Near the Intersection of the south end of the designated site boundary and the Rio Paguate | Jackpile Sandstone | MW-2 | Downgradient of all pits along Rio Moquino (Placed in Alluvium, PVC, 40 ft.) |

| Final EIS Preferred Plan | Jacobs Environmental Monitoring Plan | | Actual | |
|---|---|---|---|---|
| **Well Location** | **Well Location** | **Formation for Completion** | **New Wells** | **Variation** |
| | Near the Intersection of the south end of the designated site boundary and the Rio Paguate | Alluvium | MW-6 | Downgradient of all pits along Rio Moquino (Alluvium, PVC, 60 ft.) |
| | **GROUP B** | | | |
| | In the North Paguate Pit after backfilling | Fill | NP-OP-20E | Unknown completion |
| | In the North Paguate Pit after backfilling west thumb | Fill | NP-OP-20W | Unknown completion |
| | In the South Paguate Pit after backfilling SP-20 | Fill | SP-OP-35 | Unknown completion |
| | In the main South Paguate Pit after backfilling | Fill | SP-OP-34 | Unknown completion |
| | In the central portion of the Jackpile Pit after backfilling (2 wells) | JP-OP-41 N<br>JP-OP-41 S | | Not Installed until April 2007 |
| | **GROUP C** | | | |
| | Two locations to be selected by the Pueblo of Laguna and Department of Interior More wells may be required if the migration of contaminated groundwater off the site is detected by the proposed monitoring wells. | | | Not Installed |

In examining the monitoring wells outside the mine pits, the upgradient wells (MW-1 & MW-7) are screened in the Jackpile Sandstone. The intermediate wells (MW-2, MW-3, & MW-4) are screened in the Alluvium. The down gradient well in Oak Canyon is screened in the Jackpile Sandstone, but the downgradient well positioned to monitor the Jackpile pit and serve as the compliance well near the southern boundary of the site is in the Alluvium. **It is recommended that one of the discretionary wells be placed in the Jackpile Sandstone formation to determine the true impact to that valuable aquifer.**

Table 24 presents the surface water monitoring points. The FEIS proposed using 7 locations (unspecific in Table I-5), the Jacobs Environmental Monitoring Plan proposed six (6) descriptive locations plus each major pond in the open pits. The six (6) locations proposed in the Jacobs Environmental Monitoring Plan were sampled, plus a sampling point at the reservoir/lake. No ponded water in the open pits was sampled until April 2007, when the pond in the North Paguate Pit was sampled and analyzed.

**Table 24**
**Surface Water Monitoring Points**

| Final EIS Preferred Plan | Jacobs Environmental Monitoring Plan | Actual | |
|---|---|---|---|
| **Well Location** | **Surface Water Sampling Locations** | **Sampling Points in Closure Monitoring Program** | **Variation** |
| 7 Points (no specific locations indicated) | Upstream on the Rio Moquino | URM | |
| | Rio Moquino above the confluence | LRM | |
| | Upstream on the Rio Paguate | URP | |
| | Rio Paguate above the confluence | LRP | |
| | Rio Paguate below the confluence | RM | |
| | Rio Paguate – Ford Crossing | RT | |
| | Each major pond in the open pits | | Not done Lake/Reservoir was designated as a permanent sampling point. |

- ***Sampling Parameters***

Similarly to the sampling points, some of the sampling parameters and frequency changed (justifiably) between the time of the Final EIS and the development of the Jacobs Environmental Monitoring plan. Table 25 presents the groundwater monitoring parameter comparison.

**Table 25**
**Groundwater Parameters**

| | Final EIS | Jacobs Environmental Monitoring Plan | Actual | |
|---|---|---|---|---|
| **Duration** | **During reclamation and 10 years thereafter** | | **During Reclamation 1989-1994**[2] | **Post Reclamation 1995-2006**[1] |
| **Parameters** | **Semi-Annually** | | | |
| | pH | Annual | Twice per Year | Annual |
| | EC | Annual | | Annual |
| | Temperature | Annual | Twice per Year | Annual |
| | Bicarbonate | Once Post Closure | Plus Carbonate | Alk-Carb, Bicarb, Total |
| | Chloride | Once Post Closure | Twice per Year | Annual |

| | Final EIS | Jacobs Environmental Monitoring Plan | Actual | |
|---|---|---|---|---|
| **Duration** | **During reclamation and 10 years thereafter** | | **During Reclamation 1989-1994[2]** | **Post Reclamation 1995-2006[1]** |
| | Sulfate | Annual | Twice per Year | Annual |
| | Sodium | Once Post Closure | | Dissolved. Annual |
| | Silicon dioxide | Once Post Closure | | --- |
| | Magnesium | Once Post Closure | Manganese | Dissolved. Annual |
| | Nitrate | Once Post Closure | Twice per Year | As N, Annual |
| | Manganese | Once Post Closure | Twice per Year | Dissolved, Annual |
| | Iron | --- | Twice per Year | --- |
| | Uranium (natural) | Annual | Twice per Year | --- |
| | Radium 226 | Annual | Twice per Year | --- |
| | **Annually: Same as Semi-Annual with:** | | | |
| | Arsenic | Once Post Closure | Twice per Year | Dissolved. Annual |
| | Boron | --- | | --- |
| | [illegible] | [illegible] | Twice per Year | Dissolved. Annual |
| | [illegible] | [illegible] | Twice per Year | Dissolved, Annual |
| | [illegible] | Once Post Closure | Twice per Year | Total, Annual |
| | Cobalt | --- | | --- |
| **Parameters** | Chromium | Once Post Closure | Twice per Year | Dissolved, Annual |
| | Copper | --- | | --- |
| | Fluoride | Once Post Closure | | Annual |
| | Mercury | Once Post Closure | Twice per Year | Annual |
| | Molybdenum | Annual | Twice per Year | Dissolved, Annual |
| | Nitrogen | Nitrites – Once Post Closure | | Nitrite, as N, Annually |
| | Lead | Once Post Closure | Twice per Year | Dissolved. Annual |
| | Phosphate | Phosphorous – Once Post Closure | Total P | Orthophosphate, as P |
| | Selenium | Once Post Closure | Twice per Year | Annual |
| | Vanadium | Annual | Twice per Year | Dissolved, Annual |
| | Zinc | Once Post Closure | Twice per Year | Dissolved. Annual |
| | Ra228 | --- | Twice per Year | Dissolved. Annual |
| | Water Levels | Annual | Twice per Year | --- |
| | | ***Annual:*** | | |
| | | TDS | Twice per Year | Annual |
| | | Gross Alpha | Twice per Year | --- |
| | | Lead 210 | Twice per Year | Annual |
| | | Polonium 210 | Twice per Year | --- |
| | | ***Once Post Closure*** | | |
| | | Calcium | Twice per Year | Dissolved, Annual |
| | | Silver | Twice per Year | Dissolved. Annual |
| | | Potassium | | Dissolved, Annual |
| | | ***Once Post Closure organic substances:*** | | |
| | | Halogenated volatile organics (EPA Method 601) | 8270 Once | Not Found |
| | | Aromatic Volatile organics (EPA Method 602) | All Non Detectable | |

| | Final EIS | Jacobs Environmental Monitoring Plan | Actual | |
|---|---|---|---|---|
| **Duration** | **During reclamation and 10 years thereafter** | | **During Reclamation 1989-1994[2]** | **Post Reclamation 1995-2006[1]** |
| | | Base/neutral, acid extractables, and pesticides (EPA Method 625) | | |

[1] There was some variation year to year, but this represents the most consistent parameter list for the 10-year post closure monitoring effort
[2] Natural Resource Consultants and Testing Laboratory performed the early monitoring through about 1994 and did not analyze Ag,Zn,TSS. Hall Environmental Laboratory performed the later work and ran the list presented

Groundwater monitoring during construction (between 1989 and 1994) consisted of semi-annual monitoring of each of the monitoring wells with the exception MW-8, which was abandoned. Samples were taken in April/May and in November/December. The parameter list consisted of both sets of parameters recommended by the Jacobs Environmental Monitoring Plan. At the time of this review, water level information was only available on a semiannual basis between May 1992 and November 1994.

The post closure monitoring (1995-present) encompassed most of the parameters in the Jacobs Environmental Monitoring Plan and the sampling was performed annually across the board during April/May of each year, providing a redundancy that may not have been needed.

- ***Surface Water***

**Table 26**
**Surface Water Parameters**

| | Final EIS | Jacobs Environmental Monitoring Plan | Actual | |
|---|---|---|---|---|
| **Duration** | **During reclamation and 10 years thereafter** | | **During Reclamation 1989-1994[2]** | **Post Reclamation 1995-2006[1]** |
| | **Quarterly** | | | |
| **Parameters** | pH | Semi-Annual | Twice per Year | Annual |
| | EC | Semi-Annual | | Annual |
| | Temperature | Semi-Annual | Twice per Year | Intermittent |
| | Bicarbonate | Once Post Closure | Plus Carbonate | Annual |
| | Chloride | Once Post Closure | Twice per Year | Annual |
| | Sulfate | Semi-Annual | Twice per Year | Annual |
| | Sodium | Once Post Closure | | Annual |
| | Silicon dioxide | Once Post Closure | | Intermittent |
| | Magnesium | Once Post Closure | | Annual |
| | Nitrate | Once Post Closure | Twice per Year | Annual |

| | Final EIS | Jacobs Environmental Monitoring Plan | Actual | |
|---|---|---|---|---|
| **Duration** | **During reclamation and 10 years thereafter** | | **During Reclamation 1989-1994[2]** | **Post Reclamation 1995-2006[1]** |
| | Manganese | Once Post Closure | Twice per Year | Annual |
| | Iron | --- | Twice per Year | --- |
| | Uranium (natural) | Semi-Annual | Twice per Year | Annual |
| | Radium 226 | Quarterly | Twice per Year | Intermittent |
| | **Semi-Annually:** | | | |
| | Arsenic | Once Post Closure | Twice per Year | Annual |
| | Boron | --- | | --- |
| | Barium | Once Post Closure | Twice per Year | Annual |
| | Cadmium | Once Post Closure | Twice per Year | Annual |
| | Cyanide | Once Post Closure | Twice per Year | Annual |
| | Cobalt | --- | | --- |
| **Parameters** | Chromium | Once Post Closure | Twice per Year | Annual |
| | Copper | --- | | --- |
| | Fluoride | Once Post Closure | Twice per Year | Annual |
| | Mercury | Once Post Closure | Twice per Year | Annual |
| | Molybdenum | --- | | Annual |
| | Nitrogen | Nitrite – Once Post Closure | | Annual |
| | Lead | Once Post Closure | Twice per Year | Annual |
| | Phosphate | Phosphorous – Once Post Closure | Twice per Year | Annual |
| | Selenium | Once Post Closure | Twice per Year | Annual |
| | Vanadium | Semi-Annual | Twice per Year | Annual |
| | Zinc | Once Post Closure | Twice per Year | Annual |
| | Ra228 | --- | Twice per Year | --- |
| | Water Levels | Annual | Twice per Year | Intermittent |
| | | ***Quarterly:*** | | |
| | | TDS | Twice per Year | Annual |
| | | Gross Alpha | Twice per Year | Intermittent |
| | | ***Semi-Annual:*** | | |
| | | Lead 210 | | Intermittent |
| | | Polonium 210 | Twice per Year | Intermittent |
| | | ***Once Post Closure*** | | |
| | | Calcium | | Annual |
| | | Silver | Twice per Year | Annual |
| | | Potassium | | Annual |

Groundwater monitoring during construction (between 1989 and 1994) consisted of semi-annual monitoring of each

A total of seven surface water stations were monitored. These stations correspond to the six (6) river stations in the Plan plus the reservoir/lake. No samples were taken of the ponded water in the open pits until April 2007. Samples were analyzed for both sets of parameters recommended by the Jacobs Environmental Monitoring Plan on a semi-annual basis in April/May and November/December between 1989 and 1994 and annually in April/May between 1995 and the present.

- ***Water Quality Assessment***

The Jacobs Environmental Monitoring Plan required that the Construction Management Company audit laboratory procedures, check for anomalies and proper analytical procedures, compile data on a quarterly basis (submitted to POL and BIA), and prepare annually an Environmental Monitoring Report (containing trend graphs, discussion relative to accepted standards, discussion of anomalies, etc). Only the 1996 annual report was found (*"Jackpile Reclamation Project, Pueblo of Laguna, New Mexico, Annual Report"*, 1996). The data available to OAS was raw data. The post closure monitoring data was provided electronically predominantly directly by the analytical lab. **There appears to have been no attempt to organize or evaluate the water quality data for the post closure period.** As a result, many parameters were analyzed much more frequently than required (some that were required to be monitored only once were sampled and analyzed for 18 years. sometimes twice a year). Also, opportunities for corrections and modifications to the monitoring plan were missed. Perhaps most importantly, the lab data was not reviewed and some of the lab data is suspect.

For this section, data were evaluated for the Post Closure Period (the last 10 yrs – 1997 through 2006). It should be noted that there are complete data sets for years prior to 1997 but these ten years were considered the most appropriate for this ROD evaluation. In the evaluation of these data sets, there were both positive and negative aspects as presented in Table 27. Overall, there appears to have been no effort to evaluate the data over the last ten years. Data was not organized, laboratory QC/QA was not analyzed, trends were not evaluated, and conclusions were not drawn as to the potential hazards groundwater or surface water posed to human health and the environment.

**Table 27**
**Water Quality Data Condition**

| Positives | Negatives |
|---|---|
| • Lab sheets were clear.<br>• Analytical methods were explained.<br>• Duplicate samples and QA/QC samples were identified<br>• Detection limits were for the most part satisfactory<br>• With a few exceptions, all parameters as suggested by the Environmental Monitoring program were analyzed for each year<br>• Samples were collected consistently during the | • Data was not organized.<br>• Neither the laboratory nor the Reclamation Project performed standard quality control and quality assurance procedures.<br>• Data transfer to logical readable tables was time consuming.<br>• It appears that the data was not evaluated on an annual basis to identify trends and concerns. |

| Positives | Negatives |
|---|---|
| months of April and May for each year | • No water quality standards were defined in the ROD, Monitoring Plan or EIS.<br>• No wells were installed in the Jackpile Pit<br>• Ponded water in open pits was not sampled<br>• A well was not installed in the Jackpile Sandstone formation near the downgradient boundary<br>• Some of the depth to water measurements in the monitoring wells was not available.<br>• Flow, although not required by the ROD would be helpful in understanding the surface water flow system. |

- ***Quality Control and Quality Assurance***

In the evaluation of water quality data, quality control and quality assurance measures taken in the field and in the laboratory are of primary concern. The Jacobs Environmental Monitoring Plan goes into detail on how samples are to be collected in the field and use of duplicate samples to ensure that the laboratory analyses are acceptable. OAS was unable to obtain written sampling procedures from the current laboratory. For this review, it is assumed that these procedures were followed. Even though duplicate samples were taken, it is not apparent that these data were used anytime during the ten years of post reclamation monitoring to check on the accuracy of the lab. In addition, cation-anion balance calculations apparently, were not performed. The cation-anion balance is a long-practiced, standard procedure to check analytical data where relatively complete mineral analyses are available, which is true in this case. To calculate cation-anion balance, parameters for cations and anions are converted to meq/L and the sum of the major cations (Dissolved Calcium, Magnesium, Potassium and Sodium) should be within 5% of the sum of major anions (Total Alkalinity, Chloride, and Sulfate) in meq/L. In the case of the Post Reclamation monitoring only 42% of the samples were in the acceptable range (within 5% of each other), 33% fell within suspect range (within 5 to10% of each other) and 25% fell into the unacceptable range (greater than 10 % of each other). Every sampling period had at least one unacceptable sample. Had the data been reviewed and this simple calculation been made in a timely fashion, the laboratories could have been challenged. With only 42 % acceptable – we question the validity of the entire data sets.

- ***Data Review***

  ➢ **Hydrochemistry - Groundwater**

| EVOLUTION with RETENTION TIME | |
|---|---|
| **CATION** | **ANION** |
| Calcium | Bicarbonate |
| ↓ | ↓ |
| Magnesium | Sulfate |
| ↓ | ↓ |
| Sodium | Chloride |

Hydro Geo Chem, Inc. did a complete evaluation the hydrochemistry of the Jackpile-Paguate Mine. (Hydro Geo Chem, Inc. "*Effects of Uranium Mine Dewatering on the Water Resources of the Pueblo of Laguna, New Mexico, Final Report*", March 15, 1982) In their work, they concluded that groundwater at the mine site shows a chemical evolution from a calcium-sulfate to a sodium sulfate type. This is attributed to cation exchange along the groundwater flow path from the Zuni Uplift to the Pueblo area. When the water enters the Rio Puerco Fault Zone it mixes with more saline waters upwelling from the Permian rocks. Harold H. Zehner also evaluated groundwater at the mine site (Zehner, Harold H., US Geological Survey, Water Resources Investigation Report 85-4226, "*Hydrology and Water-Quality Monitoring Considerations, Jackpile Uranium Mine, Northwestern New Mexico*", 1985). His analysis indicated that well water in direct contact with clay and shale are dominated by sodium cations and bicarbonate/sulfate anions, whereas water from wells completed in more oxidized clay and shale are predominated by sodium – sulfate waters. Wells at the time of the Zehner (1985) study ranged in total dissolved solids between 900 and 1,500 mg/L.

Evaluation of groundwater water quality data from the 2005 sampling (the last full set of data at the site available at the preparation of the report) indicates that groundwater has evolved over time with sulfate in most cases being the predominate anion and sodium being the predominate cation in pit wells and in wells which are completed in the Jackpile Sandstone. Wells completed in the alluvium range from calcium-sulfate type water (MW-4) and calcium-bicarbonate water (MW-3) in wells crossgradient to the mined pits to magnesium–sulfate water (MW-2 and MW-6) in wells downgradient of pits. These wells can be influenced by recharge from adjacent surface waters. These data are summarized in Table 28. Total dissolved solids (TDS) have increased from those reported in the earlier studies, ranging between 671 mg/L (MW-3) and 8,080 mg/L (NPOP20E).

**Table 28**
**2005 Groundwater Quality (Major Cation and Anion) Summary**

| Well Number | Position | Total Dissolved Solids (mg/L) | Water Type | |
|---|---|---|---|---|
| | | | Predominant Cation | Predominant Anion |
| **Jackpile Sandstone Formation Wells** | | | | |
| MW-1 | Upgradient of NP Pit | 719 | Sodium | Sulfate |
| MW-7 | Upgradient of Jackpile near large area of ponded surface water runoff | 665.91 | Sodium | Bicarbonate |
| MW-5 | Downgradient of SP Pit | 1359 | Sodium | Sulfate |
| **Alluvium** | | | | |
| MW-2 | Downgradient of Jackpile Pit Adjacent Rio Moquino | 3200 | Magnesium | Sulfate |
| MW-3 | Crossgradient of NP Pit Adjacent Rio Paguate | 671.05 | Calcium | Bicarbonate |
| MW-4 | Crossgradient of SP Pit Adjacent Rio Paguate | 1069 | Calcium | Sulfate |
| MW-6 | Downgradient of all pits Adjacent Rio Moquino near South Boundary | 2460 | Magnesium | Sulfate |
| **Assumed Fill Material – both Protore and waste rock** | | | | |
| NPOP20E | Within NP Pit | 5360.5 | Sodium | Sulfate |
| NPOP20W | Within NP Pit | 8080 | Magnesium | Sulfate |
| SPOP-34 | Within SP Pit | 1329 | Sodium | Sulfate |
| SPOP-35 | Within SP Pit | 2637 | Sodium | Carbonate |

Finally, trends in total dissolved solids in groundwater water samples are quite variable. While there appeared to be slight downward trends through 2005, the data obtained for 2006 and 2007 sampling events indicate the TDS values are returning to former levels.

### ➢ *Hydrochemistry - Surface Water*

Zehner (1985) concluded that the Rio Moquino contains greater concentrations of dissolved solids than does the Rio Paguate. The mean dissolve solids concentrations at the time of the Zehner study in the Rio Moquino range from 1,600 mg/L upstream from the mine area to 1,900 mg/L just upstream from its confluence with the Rio Paguate. In the Rio Paguate the total dissolved solids increased to about 2,000 mg/L. The

Rio Moquino contained calcium, magnesium, and sodium concentrations in nearly equal proportions and sulfate concentrations greater than bicarbonate or chloride.

Again, looking at the last full set of data from 2005, there appears to be two types of water. Water samples from the Rio Paguate upstream from the mine (URP) and above the confluence (LRP) are calcium-magnesium-bicarbonate waters. Water samples from the Rio Moquino (URM, LRM) and at sampling stations on Rio Paguate below the confluence (PM) and at Ford Crossing (RT) are slightly more sodium rich with sulfate being the predominate anion. So the water is becoming more sodium-sulfate rich as it flows through the mine site.

➢ ***Contaminants***

One of the major concerns of the Record of Decision is the potential for contamination of surface water and groundwater, due to the mining and reclamation operations, to affect human health and post-reclamation land use opportunities. There were no contaminants of concern (COC) or limits set out in the ROD or FEIS. Therefore, it is difficult to determine compliance or not. OAS compared the data to available standards: Primary and Secondary Drinking Water Standards and Agricultural Standards.

Primary drinking water regulations (CFR Title 40 – "*Protection of Environment, Chapter 1 – Environmental Protection Agency, Part 141 – National Primary Drinking Water Regulations*"); and related regulations are applicable to public water systems. Secondary drinking water regulations (CFR Title 40 – "*Protection of Environment, Chapter 1 – Environmental Protection Agency, Part 143 – National Secondary Drinking Water Regulations*") control contaminants in drinking water that are non-health related, but intended to protect the public welfare. These regulations are not directly applicable to this situation, but are intended as guidelines.

<u>Primary Drinking Water Regulations</u> (Maximum Contaminant Limits)

- Fluoride – Concentrations exceeding 4 mg/L were found in all samples taken from MW-1, an upgradient well
- Lead – One excursion of the standard of 0.015 mg/L was found in MW-1
- Arsenic – One sample from MW-4 exceeded the standard of 0.01 mg/L.
- Gross Alpha – All surface waters, groundwater, and pit wells had exceedances of the Gross Alpha MCL except for the reservoir. Many had exceedances for each sampling period.

**Table 4-1**
**Gross Alpha Exceedances of the 15 pCi/L MCL**

| Location | # samples > 15 pCi/L | Range | |
|---|---|---|---|
| **Groundwater** | | | |
| MW-1 | 1 of 9 | ND | 17.33 |
| MW-2 | 10 of 10 | 12.51 | 97.67 |
| MW-3 | 6 of 9 | 31.92 | 104.85 |
| MW-4 | 9 of 9 | 20.99 | 202.3 |
| MW-5 | 3 of 9 | ND | 23.94 |
| MW-6 | 9 of 9 | ND | 118.72 |
| MW-7 | 4 of 9 | 9.11 | 40.63 |
| **Surface Water** | | | |
| NP Pond | 1 of 1 | 1468.05 | |
| Railroad Tresel | 10 of 10 | 37.59 | 214.33 |
| Lower Rio M | 7 of 10 | 16.62 | 53.05 |
| Lower Rio P | 6 of 10 | 2.24 | 106.22 |
| P-M Confluence | 8 of 10 | 11.19 | 94.03 |
| Upper Rio M | 2 of 10 | ND | 35.11 |
| Upper Rio P | 1 of 10 | ND | 25.53 |
| Paguate Lake | 0 of 6 | ND | 3.04 |
| **Pit Wells** | | | |
| NP-OP- 20 W | 10 of 10 | 159.25 | 707.71 |
| NP-OP- 20 E | 10 of 10 | 8965.97 | 67,278.82 |
| JP-OP- 41 N | 1 of 1 | 385.07 | |
| JP-OP- 41 S | 1 of 1 | 323,803.05 | |
| SP-OP-34 | 10 of 10 | 74.09 | 1490.91 |
| SP-OP-35 | 10 of 10 | 1022 | 7385.57 |

- Uranium – All Surface waters, groundwaters, and pit wells had exceedances of the total uranium. Many had exceedances for each sampling period. The Lake/Reservoir is a public recreation area used for fishing.

**Table 4-2**
**Total Uranium Exceedances of the 0.03 mg/L MCL**

| Location | # samples > 0.03 mg/L | Range | |
|---|---|---|---|
| **Groundwater** | | | |
| MW-1 | 6 of 9 | 3.87 | 6.27 |

**Table 29**
**Gross Alpha Exceedances of the MCL = 15 pCi/L**

| Location | # samples > 15 pCi/L | Range | |
|---|---|---|---|
| **Groundwater** | | | |
| MW-1 | 1 of 9 | ND | 17.33 |
| MW-2 | 10 of 10 | 12.51 | 97.67 |
| MW-3 | 6 of 9 | 31.92 | 104.85 |
| MW-4 | 9 of 9 | 20.99 | 202.3 |
| MW-5 | 3 of 9 | ND | 23.94 |
| MW-6 | 9 of 9 | ND | 118.72 |
| MW-7 | 4 of 9 | 9.11 | 40.63 |
| **Surface Water** | | | |
| NP Pond | 1 of 1 | 1468.05 | |
| Railroad Tresel | 10 of 10 | 37.59 | 214.33 |
| Lower Rio M | 7 of 10 | 16.62 | 53.05 |
| Lower Rio P | 6 of 10 | 2.24 | 106.22 |
| P-M Confluence | 8 of 10 | 11.19 | 94.03 |
| Upper Rio M | 2 of 10 | ND | 35.11 |
| Upper Rio P | 1 of 10 | ND | 25.53 |
| Lake/Reservoir | 0 of 6 | ND | 3.04 |
| **Pit Wells** | | | |
| NP-OP- 20 W | 10 of 10 | 159.25 | 707.71 |
| NP-OP- 20 E | 10 of 10 | 8965.97 | 67,278.82 |
| JP-OP- 41 N | 1 of 1 | 385.07 | |
| JP-OP- 41 S | 1 of 1 | 323,803.05 | |
| SP-OP-34 | 10 of 10 | 74.09 | 1490.91 |
| SP-OP-35 | 10 of 10 | 1022 | 7385.57 |

- Uranium – All Surface waters, groundwater, and pit wells had exceedances of the total Uranium. Many had exceedances for each sampling period. The Lake is a public recreation area used for fishing.

**Table 30**
**Total Uranium Exceedances of the MCL = 0.03 mg/L**

| Location | # samples > 0.03 mg/L | Range | |
|---|---|---|---|
| **Groundwater** | | | |
| MW-1 | 6 of 9 | 3.87 | 6.27 |
| MW-2 | 10 of 10 | 0.07 | 299.32 |
| MW-3 | 9 of 9 | 0.04 | 419.37 |
| MW-4 | 9 of 9 | 0.09 | 624.51 |
| MW-5 | 5 of 9 | 0.0002 | 11.76 |
| MW-6 | 9 of 9 | 0.07 | 69.76 |

| Location | # samples > 0.03 mg/L | Range | |
|---|---|---|---|
| MW-7 | 6 of 9 | 0.002 | 30.68 |
| **Surface Water** | | | |
| NP Pond | 1 of 1 | 3043.65 | |
| Railroad Tresel | 10 of 10 | 0.08 | 544.14 |
| Lower Rio M | 10 of 10 | 0.04 | 234.95 |
| Lower Rio P | 9 of 10 | 0.03 | 163.23 |
| P-M Confluence | 9 of 10 | 0.029 | 577.20 |
| Upper Rio M | 6 of 10 | 0.008 | 52.89 |
| Upper Rio P | 6 of 10 | 0.002 | 32.21 |
| Lake/Reservoir | 3 of 6 | 0.002 | 76.93 |
| **Pit Wells** | | | |
| NP-OP- 20 W | 10 of 10 | 0.86 | 7,928.19 |
| NP-OP- 20 E | 10 of 10 | 23.12 | 104,501.62 |
| JP-OP- 41 N | 1 of 1 | 10,832.15 | |
| JP-OP- 41 S | 1 of 1 | 427,233.06 | |
| SP-OP-34 | 9 of 9 | 0.15 | 1021.27 |
| SP-OP-35 | 9 of 9 | 5.12 | 20,538.10 |

- Radium 226 – Fewer samples exceeded the standard of 5 pCi/L. No surface water samples were above the standard. Groundwater wells exceeding the standard included (number of times exceeded are in parentheses): MW-1 (1), MW-6 (1) and MW-7 (4). All pit wells completed in fill material exceeded MCL in ***ALL*** sampling events except for NPOP20W and JPOP41N with the highest value of 384.89 pCi/l in JPOP41S.

Secondary Drinking Water Regulations

- Total Dissolved Solids – nearly all samples, both surface and groundwater, exceed the secondary standard of 500 mg/L
- Sulfate –most surface water and groundwater exceed the secondary standard of 250 mg/L
- Manganese – Several exceedances of the secondary standard of 0.05 mg/L during the 10 year monitoring period for both surface water and groundwater. These included (number of times exceeded are in parentheses) : MW-2 (10), MW-3 (3), MW-6 (7), SPOP35 (6), NPOP20W (10), NPOP20E (10), RT (2), LRM (5), LRP (6), PM (7), AND URP (8).
- pH – Two samples were in non-compliant, one from URM and the other from SPOP34.

> ***Agriculture***

Another concern of the ROD is the potential for the build up of salts in the bottom of the pits. Examination of the electric conductivity (EC) and TDS data indicates that all samples taken (in and out of the pits) present a high to very high salinity hazard for irrigation water as presented in Table29. Due to salinity alone, the groundwater is unsuitable for irrigation and stock watering.

**Table 31**
**Salinity Hazard (USDA)**

| | Conductivity ($\mu$mhos/cm) | Dissolved solids (mg/L) |
|---|---|---|
| Low salinity, no detrimental effects expected | <250 | <200 |
| Medium salinity, detrimental effects to sensitive crops | 250 – 750 | 200 – 500 |
| High salinity, adverse effects on many crops | 750 – 2250 | 500 – 1500 |
| Very high salinity, suitable only for salt tolerant plants | 2250 – 5000 | 1500 – 3000 |

**Conclusions** - Based on this review it is concluded that the intent of the ROD was met for water quality sampling, but there are some rather large data gaps. Conclusions cannot be drawn as to environmental impacts and long term health risks associated with water quality at the closed mine. The results of the radiological analyses of the monitoring well, surface water and particularly the pit wells, indicated inconsistencies in the data which should be resolved. The results of some of the pit well samples indicate levels that need to be evaluated and confirmed as soon as possible.

The four data gaps 1) the depth to water measurements were reportedly recorded in order to calculate the volume of water to be purged prior to sampling of the wells, but the record of those depths was incomplete, 2) the Jackpile pit wells were not installed until 2007, 3) the ponded water was not sampled and analyzed until 2007 (ponds were not anticipated during reclamation; they appeared in the latter half of the reclamation monitoring), and 4) a downgradient boundary well in the Jackpile Sandstone was not installed (the Jackpile Sandstone is reportedly not present at the boundary), collectively represent a major deviation from the ROD and is therefore, ***non-compliant***.

**Recommendations** - Based on these observations, the following recommendations can be made:

1. Continue sampling Jackpile pit wells, and install a discretionary well(s).
2. Install a discretionary well near the downgradient boundary. The location(s) of any discretionary well(s) should be selected in order to assess downgradient groundwater conditions. Two areas that could be considered

for this purpose are 1) upgradient from the Rio San Jose and 2) at the Mesita Dam. The downgradient monitoring wells(s) should be constructed so that the screened interval allows for both environmental compliance monitoring, as well as water table elevation measurements. The existing monitoring wells MW-5 and MW-6 were apparently screened in the bottom 10 feet for water level measurement purposes only

3. Continue sampling ponded water within pits.
4. Sample the ponded water at the north end of the site outside the Jackpile pit at least one more time. This pond extends onto the trust lands to the north where domestic cattle graze. The pond causes waste piles to be saturated and could lead to the release of contaminants from the waste pile.
5. Monitoring should continue for all the wells and surface waters until a risk assessment has been completed. Continued monitoring of surface water may be necessary to protect fowl and animals. Parameters which should be monitored include field parameters, major cations and anions, manganese, total dissolved solids, arsenic, fluoride, lead, gross alpha, radium 226, uranium (total), gross beta and Po-210. At that time sample locations can be further evaluated to determine if the monitoring can be further limited.
6. Water usage should be prohibited pending the results of additional sampling activities, QA/QC of previous lab results and the findings of the proposed Risk Assessment.
7. With the completion of sampling, data should be evaluated as to its accuracy. The laboratories should be required to perform cation-anion balances and if not within acceptable ranges, the samples should be redone.
8. A Quality Control/Quality Assurance analysis of all general chemistry, chemical and radiological reports and results needs to be conducted to evaluate the sampling procedures and analytical results. This should be followed by re-sampling of the water.
9. A risk assessment should be performed to determine the potential hazards and risks of the high levels of gross alpha, radium 226, and uranium in most samples, especially in wells in fill material and areas of public access. A risk assessment is needed prior to Resource and Land Use planning for the mine site.
10. With both surface water and groundwater samples showing some level of contamination, an evaluation should be made to determine if any contaminants have migrated beyond the compliance boundary. A compliance boundary must first be established.

- ***Subsidence***

Subsidence was of concern because of underground mining (P-7/10 Mine and PW-2/3 Mine) under sections of old highway 279. The predicted rate of subsidence is very low, but it was deemed prudent to monitor subsidence ***if and when*** the new highway 279 was temporarily closed for reclamation activities and the public was ***required*** to use the old road.

**Table 32**
**Subsidence Monitoring Requirements Comparison**

| | EIS Table 1-5 | ROD | Jacobs Environmental Monitoring Plan | Actual |
|---|---|---|---|---|
| **Sampling Points** | 89 | Item 10: Per EIS Table 1-5 | Whichever of 89 remain usable and reliable. Stations must be surveyed to 0.05 inch. | No Monitoring Done |
| **Frequency** | Quarterly | | Quarterly during time periods when New NM 279 is closed. Monthly at sites that indicate 0.5 inch in any Quarter or 1.0 inch in a year. Visual survey conducted quarterly by walking both side of Old NM 279 and document in letter to POL and BIA any obvious signs of subsidence. | |
| **Parameters** | Ground Movement | | Elevation Change | |
| **Duration** | Until SH279 is Re-aligned | | During Periods of longer than 30 days when New NM 279 is closed and Old NM 279 is in use. | |

**Conclusions** - The new highway was never closed for extended periods and the public is ***not required*** to use Old NM 279, so the letter of the ROD was met even though no monitoring took place.

**Recommendations** – Periodic inspection of Old NM 279 is recommended for subsidence and erosion.

- ***Ground Vibration***

The Jacobs Environmental Monitoring Plan states that blasting to reduce highwall slopes will be in "OPTIONAL" work package items which would be dependent on funding and POL desires.

**Table 33**
**Blast Monitoring Requirements Comparison**

| | EIS Table 1-5 | ROD | Jacobs Environmental Monitoring Plan | Actual |
|---|---|---|---|---|
| **Sampling Points** | Variable | Item 10: Per EIS Table 1-5 | 1.) Three locations in Village 2.)One location east perimeter of Village | Project Status Report No. 9, April 1990 references a Seismic Study. |
| **Frequency** | Each Blast | | Each Blast - After USGS Case Study | |
| **Parameters** | Particle and air blast | | 1.) Ground Acceleration Measured) and Ground Particle Velocity (Calculated) 2.) Air Blast | Project Status Report No. 11, June 1990 references a Blast Study of Buildings in the Village. |
| **Duration** | Until all blast is completed | | During Blasting | |

<u>**Conclusions**</u> - The blasting in the South Paguate Pit was carefully monitored and formal reports were issued. There was a damage assessment performed in the Village of Paguate where considerable damage was documented. This was followed by inspections of other pit highwalls revealing considerable integrity of highwalls and few expected safety issues related to letting the areas erode naturally. The decision by POL and BIA was to forego further blasting of highwalls, but to visually inspect the highwalls for safety issues.

<u>**Recommendations**</u> - A field assessment of the highwalls should be made to determine the hazard potential, if the walls are eroding safely or if not then if additional fencing or other corrective measures are required during the erosion process. If significant hazard potential is present, other means of slope reduction should be evaluated, such as ripping, or alternatively, localized berming or other protective measures may be warranted.

## 11. *SECURITY*

***Control of minesite access and security will continue during reclamation and monitoring activities. However, security during the monitoring phase will require cooperation from Pueblo of Laguna and BIA to prevent livestock grazing on revegetated sites.***

This ROD item has no specific requirements to be met. Project Status Reports and observations in August 2006 indicate that grazing has not been prevented. While the data indicates that the plant uptake of radionuclides and heavy metals are no threat to humans or wildlife, the groundwater concentrations for some contaminants of concern are elevated and further study is needed to determine the risk.

**Conclusions** - These requirements are addressed previously in the report. Additional sampling is required especially in the open pits and ponded water. Risk assessment may be required before grazing and other uses are allowed.

**Recommendations** - Immediate re-sampling of the pit water and ponded water is recommended. Evaluation of the radiological data is recommended.

## 12. *RECLAMATION COMPLETION*

***Reclamation will be considered complete when revegetated sites reach 90 percent of the density, frequency, foliar cover, basal cover, and production of undisturbed reference areas (but not sooner than 10 years following seeding). In addition, gamma radiation levels must be no greater than twice background over the entire minesite. Outdoor radon 222 concentrations must be no greater than 3 pCi/l. Radon daughter levels (working levels) in any remaining surface facilities must not exceed 0.03WL.***

**Conclusions** - These requirements are addressed previously in the report. See previous discussions concerning revegetation, gamma radon, radon and radon daughter levels in Sections 9 and 10. Alternative methods used to survey vegetation indicate the revegetation was successful.

**Recommendations** - Please refer to previous recommendations concerning revegetation, gamma radon, radon and radon daughter levels in Sections 9 and 10.

## 13. *POST-RECLAMATION LAND USES*

***Limited livestock grazing, light manufacturing, office space, mining and major equipment storage will be allowed. Specifically excluded are habitation and farming.***
("Jackpile Reclamation Project, Final Design Recommendations for BIA Approval", May 9, 1990 (pg 2, ¶ 3).

"9) *Elimination of the need for long-term maintenance of the site should be re-examined. Since monitoring must continue in the areas of ground water, revegetation success, and other environmental concerns, periodic inspection/repair of any noticeable erosion problems could be left under Pueblo of Laguna "care-taker" status and funded from the ground water monitoring. Although "elimination of post-reclamation maintenance" is one of the goals, situations may arise requiring some remedial action which, if performed early enough, will help to achieve the desired long-term stability. Monitoring of the inevitable livestock grazing and insuring that no farming or* *home building takes place on the site is judged to require some proactive effort."*

**Conclusions** – All ***non-compliant*** and ***potentially non-compliant*** issues need to be resolved before recommendations and discussions concerning long-term use can be undertaken.

**Recommendations** – This topic should be discussed with POL after all compliance issues have been resolved, recommended sampling and analysis completed, and risk assessment determinations have been made. Land use should be restricted, as it currently is, until all compliance issues are resolved.

## V. CONCLUSION AND RECOMMENDATIONS

| ROD Requirements |
|---|
| **1. PIT BOTTOMS** |
| **A. Backfill Levels:**<br>**1. Pits will remain as closed basins. Pit bottoms will be backfilled to at least 10 feet above the Dames and Moore (1983) projected ground water recovery levels as indicated below. A schematic diagram is shown in the FEIS:**<br><br>**Pit:** / **Proposed Minimum Backfill Level:**<br>**Jackpile 41** — **5,939 ft. amsl**<br>**North Paguate 20** — **5,958 ft. amsl**<br>**South Paguate 34** — **5,995 ft. amsl**<br>**South Paguate 35** — **6,060 ft. amsl** |
| **Conclusions** - All monitoring well installation indicate that the minimum finished grades were achieved. |
| **Recommendations** - Based on the fact that backfill elevations in all cases met or exceed the minimum proposed backfill level(s), the ROD objective has been achieved. |
| **2. A groundwater recovery level monitoring program will be implemented. Additional backfill will be added as necessary to control ponded water. The duration of the monitoring program will be a minimum of 10 years.** |
| **Conclusions** - Based on the fact that there is little elevation data where ten years of data are required and only one sample of the ponded water, accordingly, this aspect of site reclamation is considered ***non-compliant*** with the requirements of the ROD. |
| **Recommendations** -<br>• During preparation of this report, OAS made the recommendation that the two wells required by the ROD should be installed in the Jackpile Pit. This was done in April 2007<br>• Water table elevations should be monitored over a number of years to determine if the levels have stabilized, or are increasing or declining in order to evaluate whether the 10-foot below surface requirement is being met. |

- Ponded water, wherever found within the pits, should be collected for chemical analysis.

These data can then be used to assess the risk of ponded water. The data can then be analyzed to determine if the water is groundwater or surface water and whether the chemical constituents present a threat to wildlife, domestic stock, or humans. As wetland areas are diverse ecosystems that are widely valued, it may be prudent to leave the North Paguate area as a wetland if the risk analysis so justifies. If chemical analysis indicates an unacceptable risk, then the ROD requirement to add additional fill to low areas would be warranted.

**B. Backfill Materials:**

**Backfill materials will consist of protore, waste dumps H and J, and excess material obtained from waste dump resloping and stream channel clearing. These materials will be covered with 3 feet of overburden and 2 feet of topsoil (i.e. Tres Hermanos Sandstone or alluvial material).**

**Conclusions** - Although, Dumps H and J were not moved, there appears to be substantial compliance to the ROD. There was sufficient backfill material in proximity to the pits that Dumps H and J volumes were, in fact, not needed. The cover, slopes, and vegetation on these waste piles appear to be stable.

**Recommendations** – No further activities are recommended at this time.

**C. Stabilization:**

**All backfill slopes will be reduced to no greater than 3:1 (horizontal to vertical). Surface water control berms will be constructed within pit bottoms to reduce erosion and retain soil moisture for plant growth. Surface runoff will also be directed to small retention basins in the pit bottoms. All areas in the pits will then undergo surface shaping, topsoil application, and seeding as outlined under "Revegetation Methods" below.**

**1. Sloping**

**Conclusions** - There appears to be ***non-compliance*** to the letter of the ROD requirements in regard to the sloping. But many deviations were approved. It is difficult to determine pile by pile what exactly was done according to the ROD 3:1 sloping requirement and/or in accordance with the approved changes. In the OAS site inspection, there were no observed problems with the slope grades. Although there are deviations to the ROD, they appear to have met the intent of the ROD.

Some of the long runs of the terracing do appear to cause chronic blow-outs in some areas due to the pressure head of water building up along the terrace berm.

**Recommendations** - There are no corrective actions recommended

**2. Pit Berms and Retention Ponds**

**Conclusions** – The pit berms and retention ponds are not believed to be a concern for post closure health and environmental risks.

**Recommendations** - No further activities are recommended.

**D. Post-Reclamation Access:**

**Human and animal access to pit bottoms will be prevented with the use of sheep-proof fencing due to the uncertainties of predicting radionuclide and heavy metal uptake into plants (forage).**

**Conclusions** - There appears to be substantial ***non-compliance*** with both the letter and

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| intent of this Rod requirement. The fencing is clearly inadequate to prevent grazing. Installation of the perimeter fencing was approved in 1989. The perimeter fencing cannot be removed and should be maintained. At least one more sampling event of vegetation and surface water for both chemical constituents and radiological levels needs to be conducted in the North Paguate pit. Additional backfilling or permanent fence installation at North Paguate may be required based on those sampling events. |
| **Recommendations** – Additional monitoring and risk assessment is required to determine if there is any potential for impairment to the natural resources (both water and vegetation) that are needed for grazing domestic animals and wildlife. Pit bottoms need to be fenced until a recommended risk assessment is completed. |

| 2. PIT HIGHWALLS |
|---|
| A. **Jackpile Pit Highwall:** ***The top 15 feet of highwall will be cut to a 45-degree slope. All soil and unconsolidated material at the top of the highwall will be sloped 3:1. The highwall will be scaled to remove loose debris.*** |
| B. **North Paguate Pit Highwall:** **The top 15 feet of highwall will be cut to a 45-degree slope. All soil and unconsolidated material at the top of the highwall will be sloped 3:1. The highwall will be scaled to remove loose debris. Additionally, the highwall will be fenced with 6-foot chain link.** |
| C. **South Paguate Pit Highwall:** **The top 15 feet of highwall will be cut to a 45-degree slope. All soil and unconsolidated material at the top of the highwall will be sloped 3:1. The highwall will be scaled to remove loose debris. Additionally, the highwall will be fenced with 6-foot chain link.** |
| **Conclusions** - This aspect of site reclamation is considered compliant with the desires of the Pueblo of Laguna and the deviation from the ROD requirements is well substantiated with the results of the blast studies. The Jacobs Environmental Monitoring Plan listed this approach as an option that could be based on the wishes of the Pueblo of Laguna. |
| **Recommendations** - A field assessment of the highwalls and Old Highway 279 should be made periodically to make sure that the highwalls do not comprise a threat to normal Pueblo of Laguna activities, or if additional fencing or other corrective measures are required during the erosion process. If significant hazard potential is present, other means of slope reduction should be evaluated, such as ripping, or alternatively, localized berming or other protective measures may be warranted. The south-facing wall at the North Paguate pit also needs to be periodically assessed to assure that it is eroding sufficiently to cover the exposed Jackpile Sandstone, as planned. |

| 3. WASTE DUMPS |
|---|
| a. **Waste dumps H and J will be relocated to Jackpile pit as backfill.**<br>b. **Most dump slopes will be reduced to 3:1 or less and the dump slopes will be contour furrowed; exceptions are noted in Table I-4 of the FEIS.**<br>c. **Dumps which have Jackpile Sandstone on their outer surface and any Jackpile Sandstone exposed during resloping will be covered with 3 feet of overburden and 18 inches of topsoil.** |

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| d. **Berms will be installed on all dump crests to control erosion. All dump tops will slope slightly away from their outer slopes. Dump slopes will be contoured so their toes are convex to prevent formation of major gullies on slopes.**<br>e. **Additional surface treatment is outlined under "Revegetation Methods" below. Detailed modifications and treatments are presented in Table I-4 of the FEIS.** |
| **Conclusions** - OAS considers the non-use of dumps H and J (as backfill) to be a non-substantive variance from the ROD requirements, given that the features were otherwise closed in accordance with specified procedures. Issuance of Construction Specifications with alternate cover requirements from the ROD, implies an acceptance of those new depths by the relevant parties. However, the berming design that was implemented for the reclamation did not perform as expected. The areas of chronic erosion blow-outs will be considered non-compliant if radioactive material is exposed or RAD levels exceed the specified limits. |
| **Recommendations** - An evaluation of the chronic blowout areas, to determine if solutions can be designed to relieve these continuing maintenance problems, is recommended. Erosion should be monitored with appropriate equipment to determine if radiological safety is a concern. If the underlying material is non-RAD emitting, the slopes may be allowed to erode naturally. |

| 4. PROTORE STOCKPILES |
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| **All protore will be used as backfill material in pit areas. Backfill will be covered with 3 feet of overburden and 2 feet of Tres Hermanos Sandstone or alluvial material.** |
| **Conclusions** - While the letter of the ROD was not met, the revised shale barrier depth was met in all cases tested. The top soil cover was less than the revised 24 inches, but in all cases it was at least 18 inches. The gamma concentration, after placement of the cover, was below the criteria of twice background levels. |
| **Recommendations** - Although the covers did not meet the ROD or the reclamation specifications, the covers appear to be adequate for radiation safety concerns. No further action is recommended. |

| 5. SITE STABILITY AND DRAINAGE |
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| A. **Stream Stability:** |
| 1. **All contaminated soils and fill material within 100 feet of the Rio Paguate west of its confluence with the Rio Moquino, will be excavated and relocated to the open pits.** |
| **Conclusions** - The reclamation actions appear to have been compliant with this item of the ROD. |
| **Recommendations** – No further activities are recommended. |
| 2. **For the Rio Moquino, waste dumps S, T, U, N, and N2 will be pulled back 50 feet from the centerline of the stream channel. The toes of these dumps will be armored with rip-rap.** |
| **Conclusions** - The material appears to have been relocated or pulled back and armored |

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| to the specifications of the ROD and the approved changes. The Landmark/Weston Design, (Landmark Reclamation/Weston, "*Jackpile Reclamation Project, Pueblo of Laguna, New Mexico, Draft Special Case Designs*", December 1990) with the approved changes, reduced the rigor of the original erosion protection. The approved design was implemented and the letter of the ROD was met. However, the intent of the ROD is not being met because the design was inadequate to prevent erosion of the banks below the toes of the waste piles.<br><br>However, significant erosion has taken place in the past 12 years. If erosion continues at the same rate, there is serious potential for exposure of waste or contaminated soil at the toes of Piles S, T, U, N, and N2. In view of the fact that a less rigorous redesign was approved after the ROD, this unexpected erosion is a problem. If the erosion continues, waste material will be exposed creating the potential risk of human and wildlife exposure to unknown hazards, and a threat to the water quality of the Rio Moquino. |
| **Recommendations** - A more thorough inspection and hydraulic analysis and erosion study needs to be performed to determine if additional erosion protection is needed along the Rio Moquino above the confluence. A control structure on the Rio Moquino above the Pueblo of Laguna section may also be considered. |
| **3. A concrete drop structure will be constructed across the Rio Moquino approximately 400 feet above the confluence with the Rio Paguate.** |
| **Conclusions** - Due to the flash flood event that caused the stream crossing to be relocated and changed the stream flow conditions, the Rio Moquino drop structure was no longer needed. Therefore, compliance with this ROD requirement is not applicable. |
| **Recommendations** – No further activities are recommended. |
| **B. Arroyo Headcutting:** |
| **Arroyos south of waste dumps I, Y, and Y2, and the arroyo west of waste dumps FD-1 and FD-3 will be armored as shown in the FEIS Appendix A (Figure A-13). Other headcuts encountered during reclamation will also be stabilized by armoring.** |
| **Conclusions** - Based on OAS field inspection documented in the photograph, field conditions changed when the headcutting encountered a natural outcropping of sandstone. The sandstone impedes further headcutting negating the need for armoring. Therefore, this is considered a non-substantive variance from the ROD requirements. |
| **Recommendations** – No further activities are recommended at this time. |
| **C. Blocked Drainages:** |
| **1. Waste dump J and protore stockpiles SP-17BC and SP-6-B will be removed to unblock ephemeral drainage on the south side of the mine site.** |
| **Conclusions** - While the letter of the ROD was not met with regard to the movement of waste dump J, closing it in place appears to meet the intent of the ROD and no problems have arisen to date by this action. However, this area could be a physical hazard in that livestock could become entangled in the submerged fence, or stuck in the mud. |
| **Recommendations** – Because the land grant property is in close proximity to the Pueblo of Laguna, an effort should be made to jointly maintain the existing dirt banks and monitor the ponded water to determine if it presents any chemical or radiological hazard for domestic animals or wildlife. After the evaluation has been completed, a long-term |

solution may be devised.

2. **Two blocked drainages north of FD-I and F dumps will remain blocked. The remainder of the minesite, excluding open pits, will drain to Rios Paguate and Moquino.**

**Conclusions** - The letter of the ROD has been met. However, an unforeseen circumstance has arisen in that the ponded water appears to be at least a physical hazard, and potentially a chemical and radiation hazard, for the neighboring landowners and the cattle that are grazed on that land.

**Recommendations** - Since grazing livestock have access to the ponded water, POL should sample the water to determine if it presents any chemical or radiological threat to the grazing animals. Additionally, the pond has been in the past, a physical hazard for the domestic animals. The area needs to be evaluated and a long-term solution devised.

6. SURFACE FACILITIES/STRUCTURES

A. **Lease No. 1:**
**All buildings on Lease No. 1 (Jackpile lease) will be demolished and removed except for the Geology building, miner training center and buildings at the old shop and the open pit offices. The land surface (except pit highwalls and natural outcrops) will be cleared of radiological material (e.g., Jackpile Sandstone) until gamma readings of twice background, or less, are achieved. These areas will then be graded and seeded.**

B. **Lease No. 4:**
**All structures and facilities associated with the P-10 mine and new shop, including all buildings, roads, parking lots, sewage systems, power lines and poles, will be left in place. All operational and maintenance equipment, including tools, machinery, and supplies will be removed. All permanent structures and land surfaces (except pit highwalls and natural outcrops) will be cleared of radiological material until gamma readings of twice background or less are achieved. These areas will then be graded and seeded. Non-salvageable contaminated buildings and materials will be removed to the pits for disposal.**

C. **Access Routes:**
**The four major roads within the mine site will be cleared of radiological material and left after reclamation for post mining use. These access routes include: 1) the access road from P-10 and the new shop area to State Highway 279; 2) the main road through the mine; 3) the road that passes between the housing area and North Oak Canyon Mesa and then proceeds to P-10; and, 4) road to Jackpile well No. 4. All other roads (except on lease No. 4) will be removed. These areas will then be graded and seeded.**

D. **Water Wells:**
**Jackpile well No. 4, the P-10 well, the new shop well, the old shop well, and the 3 wells with associated sheltering structures (near the housing area) will be left. The pumps, riser pipe, wiring, and water storage tanks will be removed. Wells established for future monitoring purposes will also be left. All wells will be capped to prevent dust, soil, and other contaminants from entering the well casing.**

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| **E. Rail Spur:**<br>**The rail spur will be left intact. The rail spur must be cleared of radiological material until gamma readings of twice background or less are achieved. The Quirk loading dock will be demolished and hauled to the pits.** |
| **Conclusions** - Based on memoranda, discussions with M. Sarracino and an OAS field inspection, some features shown which were anticipated to be kept or salvaged were found to be of very poor condition. While not in strict compliance with the ROD, the demolition and disposal of additional facilities in no way impairs the environmental integrity of the project. Therefore, this is considered a non-substantive variance from ROD requirements. |
| **Recommendations** – No further activities are recommended. |

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| **7. DRILL HOLES** |
| **All drill holes will be plugged according to the State Engineer's requirements. A 5-foot surface concrete plug will also be placed in each hole. Any cased holes will have the casing cut off at the surface. In addition, areas around drill holes will be seeded. Any exploration roads not wanted by the Pueblo will be reclaimed.** |
| **Conclusions** - It is unclear what happened to the drill holes. No drill holes were found by CSM and that work unit was closed out on approval of all three parties. Therefore, this is considered a non-substantive variance from the ROD requirements. |
| **Recommendations** – No further activities are recommended at this time. |

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| **8. UNDERGROUND MODIFICATIONS** |
| **A. Ventilation Holes:**<br>**Vent holes will be backfilled with waste material (Dakota Sandstone and Mancos shale) to within six feet of surface. Surface casing will be removed, steel support pins installed in walls of vent holes, and sealed with a six-foot concrete plug from backfill to surface. Areas around vent holes will be contoured and seeded.** |
| **Conclusions** - It is unclear how the vent holes were closed and there are no records of how they were closed. Monthly reports indicated that the vent holes were being closed, and the work unit was closed out on approval of all three parties. Therefore, this is considered in compliance with the ROD requirements. |
| **Recommendations** – No further activities are recommended at this time. |
| **B. Adits and Declines:**<br>**A concrete bulkhead will be constructed approximately 680 feet below the portal of P-10 decline. The decline will be backfilled from bulkhead to ground surface with Dakota Sandstone and Mancos shale. Sufficient material will be placed over the portal to allow for compaction and settling. The ground surface above the buried portal will be sloped and then top-dressed and seeded. The Alpine mine entry will be bulkheaded and backfilled. Mine entries not previously plugged by backfilling will be covered. Additionally, the H-1 mine adits will be bulkheaded and backfilled and the adits at the P-13 and NJ-45 mines will be backfilled.** |
| **Conclusions** - It is unclear how the mine entries were closed. But the work units were |

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| closed out on approval of all three parties. Because all three parties approved an alternate closure method, it is presumed that the intent of the ROD was met. However, the potential for subsidence may still exist. |
| **Recommendations** - Continue to monitor the P-10 and P 2/3 areas for subsidence. Closure methods apparently presented some potential for a "controlled accident", as was stated in the Landmark Reclamation report referenced above. |

| 9. REVEGETATION METHODS |
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| **A. Top Dressing:**<br>**Following final sloping and grading, pit bottoms will be top dressed with 24 inches, waste dumps with 18 inches, and all other areas within the minesite with 12 inches of material composed primarily of Tres Hermanos Sandstone (stockpiles at three locations within the minesite). In order to meet top dressing volume requirements for the northern portion of the minesite, additional material may be obtained from a topsoil borrow area in the Rio Moquino floodplain comprising 44 acres. For the southern portion of the minesite, additional topsoil borrow material located east of J and H dumps may be needed. Following topsoil removal, disturbed borrow areas will be contoured, fertilized, seeded, and mulched.** |
| **B. Surface Preparation:**<br>**After applying top dressing, areas to be planted will be fertilized, followed by disking to a depth of 8 inches and then contour furrowing.** |
| **C. Seeding and Seed Mixtures:**<br>**Before seeding operations begin, the entire minesite will be fenced to prevent livestock grazing. In most situations, seed mixtures will be planted with a rangeland drill. Broadcast seeding combined with hydromulching may be used on inaccessible sites or if determined to be more feasible than drilling. For both methods, the seed mixture will consist mainly of native plant species possessing qualities compatible with post grazing use and adapted to the local environment (Tables 3-10 and 3-11; FEIS). Following drill seeding, straw mulch will be applied at about 2 tons per acre, and crimped into place with a notched disk.** |
| **D. Revegetation Success:**<br>**Using the Community Structure Analysis (CSA) or comparable method, plant establishment will be considered successful when revegetated sites reach 90 percent of the density, frequency, foliar cover, basal cover, and production of undisturbed reference areas (but not sooner than 10 years following seeding). Livestock grazing will be prevented until 90 percent comparability values are met. At the end of the 10-year monitoring period, if an unsuccessful trend is shown, retreatment may be necessary to achieve success criteria. In the pit bottoms, vegetation will be sampled annually for radionuclides and heavy metal uptake.** |
| **Conclusions** - The Jackpile Reclamation Project post reclamation vegetation monitoring program deviated from the requirement of the Record of Decisions. This was due to evolution in the methodologies developed, accepted and routinely accepted in the scientific community in determining vegetative success. The monitoring met the intent |

of the ROD in determining vegetation success, in that the mine was very successfully revegetated based on important vegetation parameters of cover and productivity. The revegetation did not meet the strict numerical standards of the ROD, but had vigorous and productive plant communities with desirable perennial grasses and shrubs. The condition of post-reclamation vegetation is very good to excellent, and the reclaimed mine has stable and self-sustaining diverse ecosystems, and good habitat for local wildlife. Trends in vegetation are stable for plant diversity and health.

Item 9-D of the ROD requires pit bottom vegetation be sampled annually for radiological and heavy metal uptake for a period of ten years. This was not done.

**Recommendations** - Vegetation uptake should continue to be monitored periodically in the future, especially in the pit bottoms. It has been suggested that monitoring be undertaken the next year and possibly every five years after next year; especially in the pit bottoms and in the North Paguate pit in particular.

## 10. MONITORING

**The monitoring period will vary for each parameter. Existing monitoring activities to be continued will include meteorologic sampling, air particulate sampling, radon sampling (ambient), radon exhalation sampling, gamma survey, soil and vegetation sampling, water monitoring, and subsidence. In addition, the monitoring program will be expanded to include: radon daughter levels (working levels) in any remaining mine buildings, and groundwater recovery levels/salt buildup in the open pits. The groundwater monitoring period will be of sufficient duration to determine the stable future water table conditions. Refer to Table I-5 of the FEIS for details of the monitoring plan as described under the Preferred Alternative.**

### a. Meteorologic

**Conclusions** - Meteorologic monitoring was reportedly conducted during reclamation. There is, however, no data for monitoring conducted during that time. Meteorologic monitoring data was collected during reclamation as was appropriate. However, recurring data collection equipment problems resulted in discontinuous data collecting during the post-reclamation period. At least two different monitoring equipment suppliers were tried, but the power supply problems and problems with livestock destroying the equipment continued.

**Recommendations** – No further activities are recommended.

### b. Air Particulates

**Conclusions** - The BIA Contracting Officer (CO) and Pueblo of Laguna reportedly agreed that it had been adequately demonstrated that the goals and objectives of the monitoring function had been met and agreed to discontinue the particulate sampling.

**Recommendations** – No further activities are recommended.

### c. Ambient Radon

**Conclusions** - All recorded radon gas measurements were consistently below the limit of 3.5 pCi/L set by the ROD. Because of the consistently low measurements it was mutually agreed to phase out this requirement.

**Recommendations** – No further activities are recommended.

### d. Radon Daughter Levels

| |
|---|
| **Conclusions** – No records of radon daughter level monitoring in remaining mine buildings were located. A radon daughter limit of 0.03WL working level was the specified threshold for this parameter. This is ***potentially non-compliant*** with the ROD. However, the buildings were reportedly razed at the start of reclamation. Therefore, compliance could not have been conducted or expected. |
| **Recommendations** – It is not expected, but if any of the remaining mine buildings have residual Uranium series contaminants (U, Ra 226) and the air in the buildings is relatively stale, monitoring is advised prior to extended occupancy. |
| **e. Radon Exhalation** |
| **Conclusions** - This monitoring requirement was eliminated by design at the time of monitoring program development, so while the letter of the ROD was not met, the elimination of this monitoring item was authorized when the monitoring program was adopted. |
| **Recommendations** – No further activities are recommended. |
| **f. Gamma Survey** |
| **Conclusions** – Based on this radiological measurement review, the following conclusions can be drawn:<br>• Gamma radiation monitoring levels were consistently below the 28 μR/hr requirement, or lower, and a continuous monitoring program was not warranted.<br>• The gamma radiation monitoring requirement stated that a ground survey, plus a final aerial survey, was to be conducted. The monitoring was to be conducted before seeding and after reclamation was completed. Monitoring was conducted before seeding, but the final aerial survey was not performed.<br>• It is recommended that a final ground survey, or final aerial survey, be conducted, especially on the access roads, pit bottoms and former protore piles sites to verify that these areas meet the 28 μR/hr requirement. |
| **Recommendations** - Based on these conclusions, the following recommendations can be made:<br>• Gamma radiation levels should be checked at least one more time to verify that reclaimed areas are meeting the standard of 28 μR/hr.<br>• The reclaimed mine can be released from any requirement for radon gas measurements, and should present no hazards for human health.<br>• The results of the process and sampling during the current and previous radiation monitoring should be reviewed.<br>Gamma radiation levels on the access roads, pit bottoms and former protore pile sites should be checked at least one more time, and in the future if the topography changes, to verify that those areas meet the 28 μR/hr requirement. |
| **g. Soil** |
| 1) Topsoil |
| 2) Radiologicals and Heavy Metals |
| 3) Salt Buildup |
| **Conclusions** – The topsoil, radiological and metals monitoring requirements of the ROD have been met. The salt buildup and impact to grazing has not been met. |
| **Recommendations** - The lack of salt monitoring represents ***non-compliance*** with the ROD requirements, however, the presence of well established vegetation would appear to indicate that salt buildup is not occurring. It is recommended that the pit bottom soils |

be analyzed for salt build up, and in the future if it appears that salt buildup is occurring.

**h. Radionuclide and Heavy Metal Uptake into Vegetation**

**Metals**

**Radionuclides**

**Conclusions** - The Jackpile Reclamation Project vegetation uptake-monitoring program deviated from the requirement of the ROD in that heavy metals and radionuclides were not measured for ten consecutive years after reclamation was completed. Vegetation had low levels of metal and radionuclide uptake based on sampling and laboratory analysis. It is believed that vegetation growing on the reclaimed mine presents a minimal potential for hazards to domestic livestock or human health due to the low or normal concentrations of metals and radionuclides.

**Recommendations** - As previously mentioned in ROD Item 9, it has been recommended that uptake monitoring be undertaken next year and possibly on five-year intervals thereafter in the pit bottoms and particularly in the North Paguate pit.

**i. Water Quality**

**Conclusions** - Based on this review it is concluded that the intent of the ROD was met for water quality sampling, but there are some rather large data gaps. Conclusions cannot be drawn as to environmental impacts and long term health risks associated with water quality at the closed mine. The results of the radiological analyses of the monitoring well, surface water and particularly the pit wells, indicated inconsistencies in the data which should be resolved. The results of some of the pit well samples indicate levels that need to be evaluated and confirmed as soon as possible.

The four data gaps 1) the depth to water measurements were reportedly recorded in order to calculate the volume of water to be purged prior to sampling of the wells, but the record of those depths was incomplete, 2) the Jackpile pit wells were not installed until 2007, 3) the ponded water was not sampled and analyzed until 2007 (ponds were not anticipated during reclamation; they appeared in the latter half of the reclamation monitoring), and 4) a downgradient boundary well in the Jackpile Sandstone was not installed (the Jackpile Sandstone is reportedly not present at the boundary), collectively represent a major deviation from the ROD and is therefore, ***non-compliant***.

**Recommendations** - Based on these observations, the following recommendations can be made:

1. Continue sampling Jackpile pit wells, and install a discretionary well(s).
2. Install a discretionary well near the downgradient boundary. The location(s) of any discretionary well(s) should be selected in order to assess downgradient groundwater conditions. Two areas that could be considered for this purpose are 1) upgradient from the Rio San Jose and 2) at the Mesita Dam. The downgradient monitoring wells(s) should be constructed so that the screened interval allows for both environmental compliance monitoring, as well as water table elevation measurements. The existing monitoring wells MW-5 and MW-6 were apparently screened in the bottom 10 feet for water level measurement purposes only.
3. Continue sampling ponded water within pits.
4. Sample the ponded water at the north end of the site outside the Jackpile pit at least one more time. This pond extends onto the trust lands to the north where

domestic cattle graze. The pond causes waste piles to be saturated and could lead to the release of contaminants from the waste pile.

5. Monitoring should continue for all the wells and surface waters until a risk assessment has been completed. Continued monitoring of surface water may be necessary to protect fowl and animals. Parameters which should be monitored include field parameters, major cations and anions, manganese, total dissolved solids, arsenic, fluoride, lead, gross alpha, radium 226, uranium (total), gross beta and Po-210. At that time sample locations can be further evaluated to determine if the monitoring can be further limited.
6. Water usage should be prohibited pending the results of additional sampling activities, QA/QC of previous lab results and the findings of the proposed Risk Assessment.
7. With the completion of sampling, data should be evaluated as to its accuracy. The laboratories should be required to perform cation-anion balances and if not within acceptable ranges, the samples should be redone.
8. A Quality Control/Quality Assurance analysis of all general chemistry, chemical and radiological reports and results needs to be conducted to evaluate the sampling procedures and analytical results. This should be followed by re-sampling of the water.
9. A risk assessment should be performed to determine the potential hazards and risks of the high levels of gross alpha, radium 226, and uranium in most samples, especially in wells in fill material and areas of public access. A risk assessment is needed prior to Resource and Land Use planning for the mine site.
10. With both surface water and groundwater samples showing some level of contamination, an evaluation should be made to determine if any contaminants have migrated beyond the compliance boundary. A compliance boundary must first be established.

- **Subsidence**

**Conclusions** - The new highway was never closed for extended periods and the public is ***not required*** to use Old NM 279, so the letter of the ROD was met even though no monitoring took place.

**Recommendation** – Periodic inspection of Old NM 279 is recommended for subsidence and erosion.

- **Ground Vibration**

**Conclusions** - The blasting in the South Paguate Pit was carefully monitored and formal reports were issued. There was a damage assessment performed in the Village of Paguate where considerable damage was documented. This was followed by inspections of other pit highwalls revealing considerable integrity of highwalls and few expected safety issues related to letting the areas erode naturally. The decision by POL and BIA was to forego further blasting of highwalls, but to visually inspect the highwalls for safety issues.

**Recommendations** - A field assessment of the highwalls should be made to determine the hazard potential, if the walls are eroding safely or if not then if additional fencing or other corrective measures are required during the erosion process. If significant hazard potential is present, other means of slope reduction should be evaluated, such as ripping, or alternatively, localized berming or other protective measures may be warranted.

| 11. SECURITY |
|---|
| **Control of minesite access and security will continue during reclamation and monitoring activities. However, security during the monitoring phase will require cooperation from Pueblo of Laguna and BIA to prevent livestock grazing on revegetated sites.** |
| **Conclusions** – These requirements are addressed previously in the report. Additional sampling is required especially in the open pits and ponded water. Risk assessment may be required before grazing and other uses are allowed. |
| **Recommendations** – Immediate re-sampling of the pit water and ponded water is recommended. Evaluation of the radiological data is recommended. |

| 12. RECLAMATION COMPLETION |
|---|
| **Reclamation will be considered complete when revegetated sites reach 90 percent of the density, frequency, foliar cover, basal cover, and production of undisturbed reference areas (but not sooner than 10 years following seeding). In addition, gamma radiation levels must be no greater than twice background over the entire mine site. Outdoor radon 222 concentrations must be no greater than 3 pCi/l. Radon daughter levels (working levels) in any remaining surface facilities must not exceed 0.03WL.** |
| **Conclusions** – These requirements are addressed previously in the report. See previous discussions concerning revegetation, gamma radon, radon and radon daughter levels in Sections 9 and 10. Alternative methods used to survey vegetation indicate the revegetation was successful. |
| **Recommendations** – Please refer to previous recommendations concerning revegetation, gamma radon, radon and radon daughter levels in Sections 9 and 10. |

| 13. POST-RECLAMATION LAND USES |
|---|
| **Limited livestock grazing, light manufacturing, office space, mining and major equipment storage will be allowed. Specifically excluded are habitation and farming.** |
| **Conclusions** – All ***non-compliant*** and ***potentially non-compliant*** issues need to be resolved before recommendations and discussions concerning long-term use can be undertaken. |
| **Recommendations** – This topic should be discussed with POL after all compliance issues have been resolved, recommended sampling and analysis completed, and risk assessment determinations have been made. Land use should be restricted, as it currently is, until all compliance issues are resolved. |

# APPENDIX A

# COMPARATIVE TABLES OF CONTRACTOR BREAKOUT SCHEDULES AND WORK ACTIVITIES

# TABLE A-1 Jackpile-Paquate Uranium Mine ROD Requirements, Assumed Resources and Actual References

## 1 Pit Bottoms

| | | ROD Requirement | Verify | Assumed Resources Available | Action | Actual Confirming References |
|---|---|---|---|---|---|---|
| 1A | Backfill Levels | Backfill to 10 feet above gw recovery levls | Verify meeting elevations proposed in FEIS | FEIS, App A, Fig. A-1 Proposed backfill elevations for 4 pits | Compare GW elevation to Fig A-1, check for >10 feet | Looking for GW elevation data in pit wells from post closure monitoring |
| | | | Check Actual GW recovery elevations | Before and After backfill elevation survey data | Compare survey data to gw elevation data | + Have surveyed ground elevations at pit wells |
| | | | | Remediation Report | Document activites referenced in Remed. Report | No Remediation Reports Generated |
| | | | | Aerial Photos | Confirm no open water from recent aerials | No open water from recent aerials, but Open Water in All Pits during summer 2006 |
| 1B | Backfill Materials | Backfill Materials: protore, waste dump H&J, additional waste dump and stream channel clearing/sloping. | Verify acceptable fill material, cover material, and depths used | Remediation Report - Backfill and Cover | Document activites referenced in Remed. Report | Work Unit 2E1- Movement of Backfill Material (Closed NP 3/91, SP 12/91 & JP betw 3/92 and 12/94) |
| | | Cover Material - 3 feet overburden and 2 feet topsoil | | Aerial Photos | Compare Volumes removed at dumps/other places and volumes placed in pit according to remediation documents | Work Unit 2E3- Cover Placement (closed JP 4/93-6/96, NP 4/91 - 12/92 & 8/91 - 3/92) |
| | | | | Trench or Coring Logs | Review trenching/coring logs | Confirmation Boring Grids |
| 1C | Stabilization | < 3:1 slopes | Verify Slopes | Remediation Report | Document activites referenced in Remed. Report | No Remediation Reports Generated |
| | | surface water control berms | Check surface water control | | Inspect Site - look for erosion | |
| | | surface runoff to small retention basin | Inspect for erosion, subsidence,veg. cover etc. | | Photo document site | Work Unit 2E2 - Closed 9/91-6/95 |
| | | shaping, contouring, reseeding | | | | |
| 1D | Fencing | Sheep -proof fencing of pit bottoms | | Jackpile | | Work Unit 2S5J02 closed 12/91 |
| | | | | N Paguate | | Work Unit 2S5N02 closed 12/91 |
| | | | | S. Paguate | | Work Unit 2S5S02 closed 12/91 |
| | | | | Construct Permanent Fencing All Areas | | Work Unit 2S5J09 Active 6/95 last monthly report) |

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## 2 Pit Highwalls

| | | ROD Requirement | Verify | Assumed Resources Available | Action | Actual Confirming References |
|---|---|---|---|---|---|---|
| 2A | Jackpile | Cut top 15' highwall to slope of 45 degrees | Verify slopes | FEIS, App. A, Fig. A-7 | Compare to planning diagram | Work Unit 2E5J01- No Charges |
| | | Soil and unconsolidate material to slope to 3:1 | verify loose material removal | Remediation Report | Document activites referenced in Remed. Report | No Remediation Report |
| | | Scale remaining to remove loose debris | | | Inspect and photograph site | Work Unit 2E5J02 - No Charges |
| | | Fence Highwall with 6 foot chain link | | | | Work Unit 2S5J02 closed 12/91; BUT No visible highwall fencing |
| 2B | North Paguate | Cut top 15' highwall to slope of 45 degrees | Verify slopes | FEIS, App. A, Fig. A-7 | Compare to Planning diagram | Work Unit 2E5N01 closed 12/91; BUT no highwall work done in this highwall area |
| | | Soil and unconsolidate material to slope to 3:1 | verify loose material removal | Remediation Report | Document activites referenced in Remed. Report | No Remediation Report |
| | | Scale remaining to remove loose debris | | | Inspect and photograph site | Work Unit 2E5N02 - closed 12/91; BUT no work done in this highwall area |
| | | Fence Highwall with 6 foot chain link | verify fence | | | Work Unit 2S5N02 closed 12/91; BUT No work done in this highwall area |
| 2C | South Paguate | Cut top 15' highwall to slope of 45 degrees | Verify slopes | FEIS, App. A, Fig. A-7 | Compare to Planning diagram | Work Unit 2E5S01- closed 12/91 |
| | | Soil and unconsolidate material to slope to 3:1 | verify loose material removal | Remediation Report | Document activites referenced in Remed. Report | No Remediation Report |
| | | Scale remaining to remove loose debris | | | Inspect and photograph site | Work Unit 2E5S02 - closed 12/91 |
| | | Fence Highwall with 6 foot chain link | verify fence | | | Work Unit 2S5S02 closed 12/91 |

## 3 Waste Dumps

| | | ROD Requirement | Verify | Assumed Resources Available | Action | Actual Confirming References |
|---|---|---|---|---|---|---|
| | H & J | Relocate to Jackpile for fill | | remediation report | Document activites referenced in Remed. Report | Work Unit 2E1--- and 2E2--- |
| | | Slope to 3:1; exceptions in Table I-4 | verify slopes | FEIS Table I-4, App. A Fig A-9 | Inspect and photograph site | Relates to moving waste stockpiles, cutting and grading |
| | | Exposed Jackpile Sandstone-covered by 3 feet overburden and 18 inches topsoil | verify cover | Cores or trenching logs | Compare Volumes removed at dumps/other places and volumes placed in pit according to remediation documents | Check for variation authorization |
| | | Without Jackpile Sandstone - cover with 18 inches topsoil | | Aerial Photos | | |
| | | Contour per instructions | | Maps of Dumps | | Work Unit 2T2--- |

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| | | ROD Requirement | Verify | Assumed Resources Available | Action | Actual Confirming References |
|---|---|---|---|---|---|---|

## 4 Protore Stockpiles

| | | ROD Requirement | Verify | Assumed Resources Available | Action | Actual Confirming References |
|---|---|---|---|---|---|---|
| | | | | | | Work Unit 2E2J04 |
| | | | | | | Work Unit 2E1--- |
| | | All protore will be used as backfill material in pit areas | | Maps | Document activites referenced in Remed. Report | No Remediation Report |
| | | | | Aerial Photos | Inspect and photograph site | |
| | | Backfill will be covered with 3 feet of overburden and 2 feet of TH Sandstone or alluvial material | | Cores or trench logs | Compare Volumes removed at dumps/other places and volumes placed in pit according to remediation documents | |

## 5 Site Stability and Drainage

| | | ROD Requirement | Verify | Assumed Resources Available | Action | Actual Confirming References |
|---|---|---|---|---|---|---|
| | | | | | | Work Unit 2E6N01A |
| 5A | **Stream Stability** | Remove contaminated and fill material within 100 feet of Rio Paguate west of confluence with Rio Moquino and place in pits. | Verify Removal | Remediation Report | Document activites referenced in Remed. Report | |
| | | On the Rio Moquino, pits S,T, U, N and N2 will be pulled back 50 feetfrom centerline stream channel. Toes of these dump areas will be armored with riprap | Verify channel cleared and riprap | Maps | Compare Volumes removed at dumps/other places and volumes placed in pit according to remediation documents | |
| | | Construct concrete drop structure on Rio M. 400 feet above confluence with Rio P. | Verify drop structure construction | Aerial Photos | Inspect and photograph site | Work Unit 2S5J02A |
| 5B | **Arroyo Headcutting** | Arroyos south of dumps I,Y and Y2 and arroyo west of dumps FD-1 and FD-3 will be armored as shown in FEIS,App.A,A-13 | Verify armoring | Maps, Aerial Photos, Remediation Report | Inspect and photograph site | Headcutting ceased when a sandstone outcropping was encountered, no need for this work. |
| | | Othere headcuts encountered during reclamation will be stabilized by armoring | | FEIS, App.A, A-13 | Document activites referenced in Remed. Report | |
| 5C | **Blocked Drainages** | Remove dump J and protore stockpiles SP-17BC and SP-6-B will be removed to unblock ephemeral drainage on south side of mine site. | Verify removals | Maps, Aerial Photos, Remediation Report | Inspect and photograph site | Work Unit 2E1J04 |
| | | Two blocked drainages north of FD-1 and F dumps will remain blocked | | | Document activites referenced in Remed. Report | Observed that Drainages remain Blocked |

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## 6 Surface Facilities/Structures

| | | ROD Requirement | Verify | Assumed Resources Available | Action | Actual Confirming References |
|---|---|---|---|---|---|---|
| | | | | | | N. Paguate Work Unit 2S3N01 closed 2/90 |
| 6A | **Lease No. 1 (Jackpile Lease)** | Demolish all buildings except: geology bldg, miner training center and buildings at Old Shop and Open Pit offices. | Verify demolitionm | Maps, Aerial Photos, Remediation Report | Inspect and photograph site | Jackpile Work Unit 2S3J01- activity 2/90 thru 12/90 no closure date |
| | | The land surfaces (except pit highwalls and natural outcrops) will be cleared of radiological material to < 2X background gamma | Verify gamma levels | Review gamma screening | Document activites referenced in Remed. Report | |
| | | Grade and seed these areas | Verify revegetation | | | |
| 6 B | **Lease No. 4** | All facilities and structurtes at P-10 Mine and New Shop will remain | | Maps, Aerial Photos, Remediation Report | Inspect and photograph site | South Paguate Work Unit 2S3S01 active 8/89 thru 10/91 no closure date |
| | | O&M Equipment will be removed | Verify removal | Review gamma screening | Document activites referenced in Remed. Report | |
| | | Permanenet structures and land surfaces (except pit highwalls and natural outcrops) will be cleared of radiological material to < 2X background gamma | Verify gamma levels | | | |
| | | Grade and seed these areas | Verify revegetation | | | |
| | | Non salvageable buildings will be demolished and placed inpits | | | | |
| 6 C | **Access Routes** | Four major roads within mine site will be cleared of radiological material | Verify contamination removal | Maps, Aerial Photos, Remediation Report | Inspect and photograph site | Construction Work Units: 2S5 - no activity |
| | | All other roads (except Lease No. 4) will be be removed, graded and seeded. | Verify removal and reveg. | Gamma screening | Document activites referenced in Remed. Report | Kept only roads necessary for monitoring and maintenance activities. |
| 6 D | **Water Wells** | Jackpile No. 4 well, P-10 Well, New Shop Well and 3 wells near housing areas and their sheltering will be left. All wells will be___?___ to prevent dust,soil and other contaminant from entering well casing | Verify the well locations and protections | | Inspect and photograph site | No work units, MS related what wells were dismantled and what appertenances were left at each site. |
| | | Pumps, risers, wiring and storage tanks will be removed | verify removal of these features | | Document activites referenced in Remed. Report | |
| | | Monitoring wells will remain. | | | | |

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| | | | | | | |
|---|---|---|---|---|---|---|
| 6 E | **Rail Spur** | The rails spur will be left intact but cleared of radiological material to < 2X gamma | Verify railway contamination levels | Maps, Aerial Photos, Remediation Report | Inspect and photograph site | Visual indicate remins, no specific work unit. |
| | | Qurk loadeing dock will be demolished and disposed of in the pits. | verify removal and disposal | Gamma screening | Document activites referenced in Remed. Report | Visual indicated removed, No specific work unit. |

## 7 Drilling Holes

| | | | | | | |
|---|---|---|---|---|---|---|
| | | All drill holes will be plugged according to the State Engineer's requirements | Verify well closures | Maps, Aerial Photos, Remediation Report | Inspect and photograph site | Work Unit 2S1S05 closed 3/90 |
| | | 5 foot concrete plug at surface and cut flush to surface, reseeded | | | Document activites referenced in Remed. Report | |
| | | Unwanted access roads will be removed | Verify removals and Pueblo wishes | | | |

## 8 Underground Modifications

| | | | | | | |
|---|---|---|---|---|---|---|
| 8 A | **Ventilation Holes** | Closed per instructions | Verify Closures | Maps, Aerial Photos, Remediation Report | Inspect and photograph site | Work Unit 2S1S04 closed 3/92 |
| | | | | | Document activites referenced in Remed. Report | |
| 8 B | **Adits and Declines** | P-10 will have a concrete bulkhead constructed 690 feet below portal. It will be backfilled from bulkhead to Groundsurface with Dakota Sandstone and Mancos Shale. It will be sloped and seeded | Verify Closure | Maps, Aerial Photos, Remediation Report | Inspect and photograph site | Work Unit 2S1S02 closed 2/92 |
| | | Alpine Mine Entry will be bulkheaded and backfilled. | Verify Closure | Maps, Aerial Photos, Remediation Report | Document activites referenced in Remed. Report | No work unit applied to Alpine |
| | | H-1 Mine adits will be bulkheaded and backfilled | Verify Closure | Maps, Aerial Photos, Remediation Report | | Work Unit 2S1S03 closed 2/90 |
| | | P-13 and NJ-45 Mine Adits will be backfilled | Verify Closure | Maps, Aerial Photos, Remediation Report | | Work Unit 2S1S01 closed 12/91 |
| | | Minre entries not previously plugged by backfilling will be covered. | | | | |
| | | | | | Adit PW-2/3 | Work Unit 2S1N01 closed 3/90 |
| | | | | | JP-PS-46 Enntries | Work Unit 2S1J02 no activity |
| | | | | | JP-SS-50 Entries | Work Unit 2S1J01 no activity |

| | | ROD Requirement | Verify | Assumed Resources Available | Action | Actual Confirming References |
|---|---|---|---|---|---|---|

## 9 Revegetative Methods

| | | | | | | |
|---|---|---|---|---|---|---|
| 9A | **Top Dressing** | Instructions | Verify methods used | Maps, Aerial Photos, Remediation Report | Document activites referenced in Remed. Report | |
| 9B | **Surface Preparation** | | | | | |
| 9C | **Seeding and Seed Mixtures** | | | | | |
| 9 D | **Revegetation Success** | At 10 years or later, 90 % density, foliar cover, basal cover, and production of undisturbed reference areas per CSA or comparable mthod | Perform CSA or comparable | Maps, Aerial Photos, Remediation Report | Document activites referenced in Remed. Report | Check ROD against Constructin Specifications and Memos with Changes |
| | | Livestock grazing will be prohibited until 90 % CSA met | | | Perform CSA or comparable | Work Units 2R1---activity Oct 1991 through Jun 1995 |
| | | At end of 10 year monitoring if unsuccessful, retreatment may be required | | | Make recommendations on areas in need of revegetation | |
| | | Pit bottoms must be sampled annually for radionuclide and heavy metals | Annual Sampoling | Annual vegetation Monitoring Reports | Review annual Veg monitoring reports | Review Existing Reports and 2006 Data |

## 10 Monitoring

| | | | | | | |
|---|---|---|---|---|---|---|
| | **Monitoring Plan** | FEIS, Table I-5 details monitoring plan | Verify monitoring requirements met | Monitoring Reports | Review data and compare to clean up standards | Compile and review lab data |

## 11 Remediation Completion

| | | | | | | |
|---|---|---|---|---|---|---|
| | Vegetation | 90 % CSA parameters | Verify levels met | Monitoring Reports | Review data and compare to clean up standards | No Clean Up Standards Set |
| | Gamma Radiation | < 2x background over entire site | | | | |
| | Outdoor Radon 222 | < 3 pCI/l | | | | |
| | Radon daughters | < 0.03 | | | | |

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# TABLE A-2 Reconcile Monthly Maps with Draft EIS Map Areas

a.) EIS Report Includes "Jackpile Paguate Mine Site Visual A"
This figure contains a map with waste protore and topsoil areas designated
b.) Construction Work Areas taken from Monthly Report Maps

## PROTORE, WASTE AND TOPSOIL PILES

| Planning Areas (a) | Construction Work Unit Areas (b) | What Done? | Planning Areas (a) | Construction Work Unit Areas (b) | What Done? | Planning Areas (a) | Construction Work Unit Areas (b) | What Done? |
|---|---|---|---|---|---|---|---|---|
| **JACKPILE** | | | **NORTH PAGUATE** | | | **SOUTH PAGUATE** | | |
| **Top Soil** | | | | | | | | |
| TS-1 | JP-SB-53 | Used for TS cover | TS-2A | NP-SB-26 | Used for TS cover | TS-3 | SP-SB-42 | Used for TS cover |
| B | JP-WT-16 | Used for TS cover | TS-2B | NP-SB-27 | Used for TS cover | | | |
| | | | West RM-104 | JP-SB-64 | Not used | | | |
| **Waste** | | | | | | | | |
| U | JP-WO-14 | Left in place covered | T, S | NP-WO-01 | Left in place | Q,R | SP-WT-03 | Left in place covered |
| | | | | NP-WS-31 | Used for shale cover | | SP-WO-04 | Left in place covered |
| A&B | JP-WS-15 | Used for shale cover | N,N2 | NP-WO-02 | Left in place | South Dump | SP-WS-06 | Left in place covered |
| FD-3 | JP-WO-18 (SW) | Left in place covered | | NP-WM-12 | Left in place | SP Pit Waste | SP-WS-11 | Left in place covered |
| FD-1 | JP-WO-66 | Left in place covered | | NP-DN-11 | Left in place | | SP-WO-10 | Left in place covered |
| | JP-WO-66A | Left in place covered | N | NP-WT-10 | Used for Soil cover | | SP-WM-12 | Left in place covered |
| | JP-WO-18C | Left in place covered | | | | | SP-WO-13A | Left in place covered |
| | JP-WO-18 (North) | Left in place covered | | | | | SP-WO-14 | In pit Used for backfill |
| | JP-WS-17 | Used for shale cover | | | | | SP-WO-13B | Left in place covered |
| | JP-WS-19A | Left in place covered | | | | | SP-WS-17 | Used for shale cover |
| | JP-WS-19C | Left in place covered | | | | | SP-WT-16 | left in place |
| FD-2 | JP-WS-01 | Left in place covered | | | | | SP-WS-18A | Left in place covered |
| C,D,E,F,G | JP-WT-02 | Left in place | | | | | SP-WS-18C | Left in place covered |
| | JP-WO-70 | Left in place | | | | | SP-WT-19 | Used for soil cover |
| H | JP-WO-06 | Left in place covered | | | | | SP-WS-20 | Used for shale cover |
| X,I,Y,Y2 | JP-WO-03B | Left in place covered | | | | | SP-WS-37 | Left in place covered |
| | JP-WO-03 | Left in place covered | | | | | SP-WT-15 | Used for soil cover |
| | JP-WO-04 | Left in place covered | | | | | SP-WM-36 | Left in place covered |
| | JP-WO-07 | Left in place covered | | | | | SP-WS-07 | Used for shale cover |
| W | JP-WO-11 (South) | Left in place covered | | | | | SP-WS-08 | Used for shale cover |
| | JP-WO-12 | Left in place covered | | | | | SP-WS-09 | Used for shale cover |
| | JP-WS-08 | Left in place covered | | | | | SP-WS-18B | Left in place covered |
| | JP-WO-10 | Left in place covered | | | | L, K | SP-WT-05 | Left in place covered |
| | JP-WO-09 | Left in place covered | | | | | SP-WO-38 | Left in place covered |
| V | JP-WS-13 | Left in place covered | | | | | | |
| | JP-WO-11 (North) | Left in place covered | | | | | | |
| | JP-WO-20 | Left in place covered | | | | | | |
| J | JP-WO-05 | Left in place covered | | | | | | |
| Jackpile Pit Waste | JP-WO-72 | Used for backfill | | | | | | |
| **Protore** | | | | | | | | |
| SP-6-A | JP-PS-24 | Hauled to JP-OP-41 | SP-2-C | NP-PS-17 | Hauled to NP-OP-20 | SP-1-A | SP-PS-01 | Hauled to NP-OP-20 |
| SP-6-B | JP-PS-25 | Hauled to JP-OP-41 | 1B | NP-PS-18 | Hauled to NP-OP-20 | 4-1 | SP-PS-02 | Hauled to SP-OP-34 |
| SP-1, J-1A,J-1-A,JLG | JP-PS-22 | In JP-OP-41 covered | 10, SP-2-D,SP-1-C | NP-PS-15 | Hauled to NP-OP-20 | PLG | | In SP-OP-34 covered |
| 17-E | JP-PS-23 | Hauled to JP-OP-41 | | NP-PS-16 | Hauled to NP-OP-20 | PLG-1 | | In SP-OP-34 covered |
| J2 | JP-PS-26 | Hauled to JP-OP-41 | 2E | NP-PS-14 | Hauled to NP-OP-20 | 1-D | | In SP-OP-34 covered |
| J1 | JP-PS-27 | Hauled to JP-OP-41 | 1E | ? | In NP-OP-20 covered | | | |
| SP-17BC | Off Work Unit Map | Hauled to JP-OP-41 | SP-1 | NP-PS-13 | Hauled to NP-OP-20 | | | |
| | | | SP-1-A | SP--PS-01 | Hauled to NP-OP-20 | | | |

## SHALE COVER OPERATIONS

| JACKPILE | NORTH PAGUATE | SOUTH PAGUATE |
|---|---|---|
| | NP-D1 | SP-D1 |
| None Available | NP-D2 | SP-D2 |
| | NP-D3 | SP-D3 |
| | NP-D4 | SP-D4 |
| | NP-D5 | SP-D5 |
| | NP-D6 | SP-D6 |
| | NP-D7 | SP-D7 |
| | NP-D8 | SP-D8 |
| | NP-D9 | |
| | NP-D10 | SP-D11 |

## TOPSOILCOVER

| JACKPILE | NORTH PAGUATE | SOUTH PAGUATE |
|---|---|---|
| JP-D1 | NP-D1 | SP-D1 |
| JP-D2 | NP-D2 | SP-D2 |
| JP-D3 | NP-D3 | SP-D3 |
| JP-D4A | NP-D4 | SP-D4 |
| JP-D4B | NP-D5 | SP-D5 |
| JP-D5 | NP-D6 | SP-D6 |
| JP-D6 | NP-D7 | SP-D7 |
| JP-D7 | NP-D8 | SP-D8 |
| | NP-D9 | |
| JP-D8A | NP-D10 | SP-D10 |
| JP-D8B | | SP-D11 |
| JP-D9A | | |
| JP-D9B | | |
| | | |
| JP-D11 | | |
| JP-D12 | | |
| JP-D13 | | |
| JP-D14 | | |
| JP-D15 | | |

# TABLE A-3 Jackpile ROD vs. Work Packages

| Used Marvin's Closeout Summary Table and Added entries from Monthly Report "Detail for PTD" | | Marvin's Closeout Dates | Coded for Various Pile Categories | | | | | ROD Categories | Relate Draft EIS Piles to Work Units |
|---|---|---|---|---|---|---|---|---|---|
| | BACKFILLING | | Protore | Waste | Shale | Topsoil | Contam. | | |
| | | | | | | | | | EIS Protore, Waste & Topsoil Piles |
| Jackpile | J = Jackpile | | | | | | | | |
| | | | | | | | | | |
| 2E1J01/01B | Haul Roads and Ramps thru PY93 | | | | | | | | |
| 2E1J02 | JP-PS-23 to Backfill (JP-OP-41) | Dec-92 | P | | | | | 1B | move Protore pile 17E |
| 2E1J03 | JP-PS-24 Pit Backfill (JP-OP-41) | Apr-93 | P | | | | | 1B | Move Protore Pile SP-6A |
| 2E1J04 | JP-PS-25 Pit Backfill (JP-OP-41) | Apr-93 | P | | | | | 1B | 5C Partial - moved Protore SP6B |
| 2E1J05 | Pit Backfill JP-PS-26 (JP-OP-41) | Feb-92 | P | | | | | 1B | Move Protore J2 |
| 2E1J06 | Pit Backfill JP-WO-10 (JP-OP-41) | Feb-92 | | W | | | | 1B | Move Waste W |
| 2E1J07 | JP-PS-27 to Backfill (JP-OP-41) | Dec-92 | P | | | | | 1B | Move Protore J1 |
| 2E1J08 | JP-WO-07 Pit Backfill (JP-OP-41) | Apr-93 | | W | | | | 1B | Move Waste Piles X,I,Y,Y2 |
| 2E1J09 | JP-WO-12 to Pit Backfill (JP-OP-41) | Jul-94 | | W | | | | 1B | Move Waste W |
| 2E1J10 | JP-WS-08 to JP-OP-41 | Not Used | | W | | | | 1B | Move Waste W |
| 2E1J11 | JP-WS-15 Pit Backfill (JP-OP-41) | Nov-94 | | W | | | | 1B | Move Waste A,B |
| 2E1J12 | JP-WO-71 Pit Backfill (JP-OP-41) | Sep-93 | | W | | | | 1B | |
| 2E1J13 | JP-WO-03 Pit Backfill (JP-OP-41) | Feb-92 | | W | | | | 1B | Move Waste Piles X,I,Y,Y2 |
| 2E1J14 | JP-WS-13 & WO-20 Backfill (JP-OP-42) | Dec-92 | | W | | | | 1B | Move Waste V |
| 2E1J15 | Jackpile Haul Roads- Force Account | | | | | | | | |
| | | | | | | | | | |
| North Paguate | N=North Paguate | | | | | | | | |
| | | | | | | | | | |
| 2E1N01 | Build No Paguate Haul Roads | Nov-90 | | | | | | | |
| 2E1N02 | Haul to Pit NP-PS-17 | Sep-91 | P | | | | | 1B | Move Protore SP-2-C |
| 2E1N03 | NP-PS-18 to No.Paguate Pit | Nov-90 | P | | | | | 1B | Move Protore 1B |
| 2E1N04 | Haul NP-PS-14 to Pit | Feb-90 | P | | | | | 1B | Move Protore 2E |
| 2E1N05 | NP-PS-15 to No.Paguate Pit | Nov-90 | P | | | | | 1B | Move Protore 10,SP-2-D, Sp-1-C |
| 2E1N06 | NP-PS-16 to No. Paguate Pit | Nov-90 | P | | | | | 1B | Move Protore 10,SP-2-D, Sp-1-C |
| 2E1N07 | SP-PS-01 to No. Paguate Pit | Nov-90 | P | | | | | 1B | Move Protore SP-1-A |
| 2E1N08 | No Work Unit Assigned this WBS | | | | | | | | |
| 2E1N09 | No Work Unit Assigned this WBS | | | | | | | | |
| 2E1N10 | NP-WT-10 Pit Backfill | Sep-91 | | W | | | | 1B | Move Waste Pile N |
| 2E1N11 | Relocate NP-PS-13 to Pit | Feb-90 | P | | | | | 1B | Move Protore SP-1 |
| 2E1N12 | Cut Slopes NP-OP-19 | Feb-90 | | | | | | | |
| | | | | | | | | | |
| South Paguate | S=South Paguate | | | | | | | | |
| | | | | | | | | | |
| 2E1S01 | Construct Sp Haul Roads | | | | | | | | |
| 2E1S02 | Pit Backfill SP-PS-02 | Sep-91 | P | | | | | 1B | Move Protore 4-1 |
| 2E1S03 | SP-PS-02 Additional Volume | Dec-91 | P | | | | | 1B | Move Protore 4-1 |
| | | | | | | | | | |

05000102

| Used Marvin's Closeout Summary Table and Added entries from Monthly Report "Detail for PTD" | | Marvin's Closeout Dates | Coded for Various Pile Categories | | | | | ROD Categories | Relate Draft EIS Piles to Work Units |
|---|---|---|---|---|---|---|---|---|---|
| | | | Protore | Waste | Shale | Topsoil | Contam. | | EIS Protore, Waste & Topsoil Piles |
| | DUMP SLOPING | | | | | | | | |
| Jackpile | J = Jackpile | | | | | | | | |
| 2E2J01 | JP-WO-11 Backfill | Jul-94 | | w | | | | 1B | Slope Waste V and W |
| 2E2J02 | JP-WT-16D Backfill | Jul-94 | | w | | | | 1B | |
| 2E2J03 | JP-WS-17 to Backfill (Dozers) | Dec-92 | | w | | | | 1B | Slope FD-1 |
| 2E2J04 | JP-PS-22 Cut Slopes | Dec-92 | P | | P | | | | Slope Protore SP-1, J-1A,J-1-A,JLG |
| 2E2J05 | Cut JP-WO-72 Slopes | Sep-92 | | w | | | | | Slope Jackpile Pit Waste |
| 2E2J06 | No Work Unit Assigned this WBS | | | | | | | | |
| 2E2J07 | No Work Unit Assigned this WBS | | | | | | | | |
| 2E2J08 | Cut JP-WS-01 Slopes | NC | | | | | | | Slope FD-2 |
| 2E2J09 | Deleted (JP-WT-02A/02B/02C) | | | | | | | | Slope C,D,F,G |
| 2E2J10 | JP-WO-73 Pit Backfill | Sep-93 | | w | | | | 1B | |
| 2E2J11 | No Work Unit Assigned this WBS | | | | | | | | |
| 2E2J12 | JP-WO-06 Cut Slopes | Apr-93 | | w | | | | | Slope Wast e H |
| 2E2J12 | JP-WO-06 Cut Slopes | Sep-93 | | w | | | | | Slope Waste H |
| 2E2J13 | JP-WO-08 / WO-12 Cut Slopes | Apr-93 | | w | | | | | Slope Waste W |
| 2E2J14 | JP-WO-11 Cut Slopes | Feb-92 | | w | | | | | Slope Waste V & W |
| 2E2J15 | Cut Slopes JP-WS-15 (15A/15B Slopes) | Sep-91 | | w | | | | | Slope Waste A&B |
| 2E2J16 | JP-WO-05 Cut Slopes | Apr-93 | | w | | | | | |
| 2E2J17 | Cut JP-WT-16A/16B/16C/Slopes | NC | | w | | | | | Slope Jackpile Pit Waste |
| 2E2J18 | Shale to JP-D4 | | | | s | | | | |
| 2E2J19 | JP-WO-73 Pit Backfill | Apr-93 | | w | | | | 1B | |
| 2E2J20 | Cut Slope JP-WO-14 | Dec-91 | | w | | | | | Slope Waste U |
| 2E2J21 | JP-WS-15A Cut Slopes | Feb-92 | | w | | | | | Slope A&B |
| 2E2J22 | JP-WS-19 B & C | Sep-92 | | w | | | | | Slope Waste FD-1 |
| 2E2J23 | Cut JP-WS-19C Slopes | | | w | | | | | Slope Waste FD-1 |
| 2E2J24 | Cut Slopes JP-WO-66 | Sep-91 | | w | | | | | Slope Waste FD-1 |
| 2E2J25 | Deleted (JP-WO-70) | | | w | | | | | Slope Waste C,D,E,F,G |
| 2E2J26 | JP-WO-18A / 66A Cut Slopes | Dec-92 | | w | | | | | Slope Waste FD-1 |
| 2E2J27 | Cut Slopes JP-WO-18B & 66C | Sep-92 | | w | | | | | Slope Waste FD-1 |
| 2E2J28 | JP-WO-18C / 66C | Dec-92 | | w | | | | | Slope Waste FD-1 |
| 2E2J29 | JP-WO-03A Cut Slopes | Jul-94 | | w | | | | | Slope Waste X,I,Y,Y2 |
| 2E2J30 | JP-WO-03B Cut Slopes | Sep-93 | | w | | | | | Slope Waste X,I,Y,Y2 |
| 2E2J31 | JP-WO-04A Cut Slopes | Sep-93 | | w | | | | | Slope Waste X,I,Y,Y2 |
| 2E2J32 | JP-WO-04B Cut Slopes | Sep-93 | | w | | | | | Slope Waste X,I,Y,Y2 |
| | | | | | | | | | |
| North Paguate | N=North Paguate | | | | | | | | |
| | | | | | | | | | |
| 2E2N01 | Cut Bench NP-WO-01 | Feb-92 | | w | | | | | Slope Wast T&S |
| 2E2N02 | Cut Slopes NP-WO-02 | Sep-91 | | w | | | | | Slope N, N2 |
| 2E2N03 | Cut Slopes N P-WS-03 | Sep-91 | | w | | | | | |
| 2E2N04 | Slope NP-WO-04 | Nov-90 | | w | | | | | |
| 2E2N05 | Cut NP-WO-06 Slopes | NC | | | | | | | |
| 2E2N06 | Cut NP-WT-09 Slopes | NC | | | | | | | |
| 2E2N07 | Regrade NP-DN-22 | Dec-91 | | | | | | | |
| 2E2N08 | Cut Slopes NP-WM-12 | Sep-91 | | w | | | | | Slope N, N2 |
| 2E2N09 | Slope NP-HW-25 | Nov-90 | | | | | | | |

05000103

| Used Marvin's Closeout Summary Table and Added entries from Monthly Report "Detail for PTD" | | Marvin's Closeout Dates | Coded for Various Pile Categories | | | | | ROD Categories | Relate Draft EIS Piles to Work Units |
|---|---|---|---|---|---|---|---|---|---|
| | | | Protore | Waste | Shale | Topsoil | Contam. | | EIS Protore, Waste & Topsoil Piles |
| **South Paguate** | S=South Paguate | | | | | | | | |
| 2E2S01 | Slope SP-WO-13A / WO-10 | Nov-90 | | w | | | | | Slope SP Pit Waste |
| 2E2S02 | Cut Slopes SP-WS-17 | Dec-91 | | w | | | | | Slope SP Pit Waste |
| 2E2S03 | Cut Slope SP-WO-13B & WS-18A | Dec-91 | | w | | | | | Slope SP Pit Waste |
| 2E2S04 | Cut SP-WO-14 Slopes | Feb-90 | | w | | | | | Slope SP Pit Waste |
| 2E2S05 | Cut SP-WS-18B Slopes | NC | | w | | | | | Slope SP Pit Waste |
| 2E2S06 | Slope SP-WS-18C / WT-19 | Nov-90 | | w | | | | | Slope SP Pit Waste |
| 2E2S07 | Slope SP-WT-03 | Nov-90 | | w | | | | | |
| 2E2S08A | SP-OP-34 Backfill (Force Account) SP-WT-06 | NC | | w | | | | 1B | slope Q&R |
| 2E2S09 | Cut SP-WO-38 Slopes | Feb-90 | | w | | | | | Slope L&K |
| 2E2S10 | SP-WS-06 | Deleted | | w | | | | | |
| 2E2S11 | Slope SP-WT-19A | Nov-90 | | w | | | | | Slope SP Pit Waste |
| 2E2S12 | Slope SP-WM-12 and WS-11 | Nov-90 | | w | | | | | Slope SP Pit Waste |
| 2E2S13 | SP-WT-15A,B | Deleted | | | | | | | Slope SP Pit Waste |
| 2E2S14 | Backfill SP-OP-34 (D4-West) | Dec-91 | | | | | | | |
| 2E2S15 | Slope SP-WT -16/37 | Nov-90 | | w | | | | | Slope SP Pit Waste |
| 2E2S16 | Backfill SP-OP-34 (D4-East) | Dec-91 | | | | | | 1B | |
| 2E2S17 | Backfill SP-OP-34 (SP-14) | Dec-91 | | | | | | 1B | |
| 2E2S18 | Backfill SP-OP-34(Sh-2) | Dec-91 | | | | | | 1B | |
| 2E2S19 | Misc. So. Paguate Sloping | Nov-90 | | | | | | | |
| | COVER PLACEMENT | | | | | | | | |
| **Jackpile** | J = Jackpile | | | | | | | | |
| 2E3J01 | Haul Soil from JP-SB-53 to D4 Soil Cover | Apr-93 | | | | T | | 1B | |
| 2E3J02 | Haul Soil from JP-SB-53 to D5 Soil Cover | Apr-93 | | | | T | | 1B | |
| 2E3J03 | Haul Soil from JP-SB-53 to D6 Soil Cover | | | | | T | | 1B | |
| 2E3J04 | Haul Soil from JP-SB-53 to D9A | Jul-94 | | | | T | | 1B | |
| 2E3J05 | Haul Soil from JP-SB-53 to D1 | Nov-94 | | | | T | | 1B | |
| 2E3J06 | Haul Soil from JP-SB-53 to D3 | | | | | T | | 1B | |
| 2E3J07 | Haul Soil from JP-SB-53 to D2 | | | | | T | | 1B | |
| 2E3J08 | Haul Soil from JP-SB-64 to D7 | | | | | T | | 1B | |
| 2E3J08A | JP-WO-07 Pit Backfill | Sep-93 | | w | | | | 1B | Related to Piles X,I,Y,Y2 |
| 2E3J09 | Haul Soil from JP-SB-64 to D11 | Nov-94 | | | | T | | 1B | |
| 2E3J10 | Haul Soil from JP-SB-64 to D12 or D12A | Sep-93 | | | | T | | 1B | |
| 2E3J11 | Haul Soil from JP-SB-54 to D16 | Sep-93 | | | | T | | 1B | |
| 2E3J12 | Haul Soil from JP-SB-54 to D15 | Jul-94 | | | | T | | 1B | |
| 2E3J12 | Soil JP-D15 | Sep-93 | | | | | | 1B | |
| 2E3J13 | Soil to JP-D4 | Jul-94 | | | | | | 1B | |
| 2E3J14 | 1990 (JP-SB-54) | Deleted | | | | T | | 1B | |
| 2E3J15 | Topsoil to H-1 mine area | Dec-91 | | | | T | | 1B | |
| 2E3J16 | Soil to JP-D13 | Jul-94 | | | | | | 1B | |
| 2E3J17 | Soil JP-D8B | | | | | | | 1B | |
| 2E3J18 | Haul Shale from JP-WS-19 to D4 | NC | | | s | | | 1B | |
| 2E3J19 | Haul Shale from JP-WS-15 to D1 | NC | | | s | | | 1B | |
| 2E3J20 | Haul Shale from JP-WS-15 to D2 Shale Cover | Apr-93 | | | s | | | 1B | |
| 2E3J21 | Haul Shale from JP-WS-15 to D7 | NC | | | s | | | 1B | |
| 2E3J22 | Haul Shale from JP-WS-15 to D11 | NC | | | s | | | 1B | |
| 2E3J23 | Haul Shale from JP-WS-15 to D12 | Apr-93 | | | s | | | 1B | |
| 2E3J23 | Shale JP-D15 | Sep-93 | | | s | | | 1B | |
| 2E3J24 | Haul Shale from JP-WT-02 TO D8A | Nov-94 | | | s | | | 1B | Haul Shale C,D,E,F,G |
| 2E3J24 | JP-WO-02 | NC | | | | | | 1B | |
| 2E3J25 | | | | | | | | | |
| 2E3J26 | Shale Cover JP-D13 | Jul-94 | | | s | | | | |
| 2E3J27 | Shale JP-D14 or D4 | Sep-93 | | | s | | | 1B | |
| 2E3J28 | Haul Shale from JP-WT-02 to D15 | Jul-94 | | | s | | | 1B | |
| 2E3J29 | Haul Shale from JP-WT-02 to D16 | Sep-93 | | | s | | | 1B | |

05000104

| Used Marvin's Closeout Summary Table and Added entries from Monthly Report "Detail for PTD" | | Marvin's Closeout Dates | Coded for Various Pile Categories | | | | | ROD Categories | Relate Draft EIS Piles to Work Units |
|---|---|---|---|---|---|---|---|---|---|
| | | | Protore | Waste | Shale | Topsoil | Contam. | | EIS Protore, Waste & Topsoil Piles |
| North Paguate | N=North Paguate | | | | | | | | |
| 2E3N01 | Haul Soil from NP-SB-61 to NP-D8 | Sep-92 | | | | T | | 1B | |
| 2E3N02 | Haul Soil from NP-SB-26 to NP-D2 | Sep-91 | | | | T | | 1B | |
| 2E3N02 | Soil Cover NP-D7 | Sep-92 | | | | | | 1B | |
| 2E3N03 | Haul Soil from NP-SB-27 to NP-D7 | NC | | | | T | | 1B | |
| 2E3N04 | Haul Soil from NP-SB-27 to D9 | Feb-92 | | | | T | | 1B | |
| 2E3N05 | Haul Soil from NP-SB-27 to D6 | Dec-92 | | | | T | | 1B | |
| 2E3N06 | Haul Soil from NP-SB-61 to NP-D9 | Feb-92 | | | | T | | 1B | |
| 2E3N07 | Haul Soil from SP-DN-61 to NP-D4 | Nov-91 | | | | T | | 1B | |
| 2E3N08 | Haul Soil from SP-DN-61 to NP-D1 | Nov-91 | | | | T | | 1B | |
| 2E3N09 | Haul Soil from SP-DN-61 to NP-D3 | Sep-91 | | | | T | | 1B | |
| 2E3N10 | Haul Soil from SP-DN-61 to NP-D5 | Sep-91 | | | | T | | 1B | |
| 2E3N11 | Haul Soil from SP-DN-61 to NP-D10 | Sep-92 | | | | T | | 1B | |
| 2E3N12 | Soil to NP-D6 (Benches) | Sep-92 | | | | | | 1B | |
| 2E3N13 | Haul Shale Cover From NP-WS-31 to N P-D9 | Feb-92 | | | s | | | 1B | Haul shale from T&S |
| 2E3N14 | Shale Borrow to N P-D4 | Sep-91 | | | s | | | 1B | |
| 2E3N15 | Shale Borrow to NP-D5 | Sep-91 | | | s | | | 1B | |
| 2E3N16 | Haul Shale from NP-WS-31 to NP-D8 | Feb-92 | | | s | | | 1B | Haul shale from T&S |
| 2E3N16 | Shale Cover NP-D8 | Sep-92 | | | s | | | 1B | |
| 2E3N17 | Haul Shale from NP-WS-31 to NP-D10 | Sep-92 | | | s | | | 1B | Haul shale from T&S |
| 2E3N18 | Haul Shale From NP-WS-03 to NP-D3 | Sep-91 | | | s | | | 1B | |
| 2E3N19 | Haul Shale From NP-WS-03 to NP-D3 | Sep-91 | | | s | | | 1B | |
| 2E3N20 | No Work Package Assigned this WBS# | | | | | | | | |
| 2E3N21 | Haul Shale from NP-WS-03 to NP-D1 | NC | | | | | | 1B | |
| South Paguate | S=South Paguate | | | | | | | | |
| 2E3S01 | Topsoil Soil Borrow SP-OP-35 (SP-D1) from SP-SB | Sep-91 | | | | T | | 1B | |
| 2E3S02 | Topsoil Soil Borrow SP=WS-17(SP-D2) from SP-SB | Dec-91 | | | | T | | 1B | |
| 2E3S03 | Topsoil Soil Borrow to SP-D3 from SP-SB-44 | Dec-91 | | | | T | | 1B | |
| 2E3S04 | Haul Soil from SP-SB-42 to SP-D4 | Feb-92 | | | | T | | 1B | |
| 2E3S05 | Haul Soil from SP-SB-42 to SP-D5 | Feb-92 | | | | T | | 1B | |
| 2E3S06 | Haul Soil from SP-SB-42 to SP-D6 | Feb-92 | | | | T | | 1B | |
| 2E3S07 | Haul Soil from SP-SB-42 to SP-D7 | Feb-92 | | | | T | | 1B | |
| 2E3S08 | Topsoil to SP-D8 from SP-SB-44 | Dec-91 | | | | T | | 1B | |
| 2E3S09 | Topsoil to SP-D9 from SP-SB-42 | Dec-91 | | | | T | | 1B | |
| 2E3S10 | Haul Soil fom SP-SB-42 to SP-D10 | Not Used | | | | | | 1B | |
| 2E3S11 | Topsoil to SP-D11 from SP-SB-42 | Dec-91 | | | | T | | 1B | |
| 2E3S12 | Soil Cover to SP-D12 from SP-SB-43 | Feb-92 | | | | T | | 1B | |
| 2E3S13 | Topsoil to SP-D1B from SP-SB-50 | Nov-91 | | | | T | | 1B | |
| 2E3S14 | Shale Cover SP-WO-13A from SP-WS-17 | Sep-91 | | | s | | | 1B | |
| 2E3S15 | Shale Borrow (SP-13B) from SP-WS-15 | Not Used | | | | | | 1B | |
| 2E3S16 | Shale Borrow for SP-PS-01 from SP-WS-07 | Sep-91 | | | s | | | 1B | Remove shale from SPPit Waste for Cover |
| 2E3S17 | Shale Cover to SP-14 from SP-WS-07 | Dec-91 | | | s | | | 1B | Remove shale from SPPit Waste for Cover |
| 2E3S18 | Haul Shale Borrow from SP-WS-07 to SP-WO-04 | Sep-91 | | | s | | | 1B | Cover Q,R with shale from SP Pit Waste |
| 2E3S19 | Haul Shale from Sp-WS-07 to SP-D10 | Nov-91 | | | | T | | 1B | Remove shale from SPPit Waste for Cover |
| 2E3S20 | Haul Shale to SP-38 Shale from SP-WS-07 | Sep-91 | | | s | | | 1B | Remove shale from SPPit Waste for Cover |
| 2E3S21 | Haul Shale Cover from SP-WS-07 to SP- WO-10 | Sep-91 | | | s | | | 1B | Remove shale from SPPit Waste for Cover |
| | **CONTAMINATED SOIL EXCAVATION** | | | | | | | | |
| Jackpile | J = Jackpile | | | | | | | | |
| 2E4J01 | HaulJP-CS-36 to JP-OP-41 for Backfill | Feb-92 | | | | | c | | |
| 2E4J02 | Haul JP-CS-37/38 to JP-OP-41 Backfill | Dec-92 | | | | | c | | |
| 2E4J03 | No work Package assigned this WBS | | | | | | | | |
| 2E4J04 | Combined into 2E4J02 | | | | | | | | |

05000105

| Used Marvin's Closeout Summary Table and Added entries from Monthly Report "Detail for PTD" | | Marvin's Closeout Dates | Coded for Various Pile Categories | | | | | ROD Categories | Relate Draft EIS Piles to Work Units |
|---|---|---|---|---|---|---|---|---|---|
| | | | Protore | Waste | Shale | Topsoil | Contam. | | EIS Protore, Waste & Topsoil Piles |
| **North Paguate** | N=North Paguate | | | | | | | | |
| 2E4N01 | Haul Pit Backfill from NP-CS-24/23 to NP-OP-20 | Sep-91 | | | | | c | | |
| 2E4N01 A | N. Rio Paguate Backfill-East | Dec-91 | | | | | c | | |
| 2E4N01 B | N. Rio Paguate Backfill-West | Dec-91 | | | | | c | | |
| | | | | | | | | | |
| **South Paguate** | S=South Paguate | | | | | | | | |
| 2E4S01 | SP-SS-27/28, CS | NC | | | | | | | |
| 2E4S01 | FM S-CS-27/28/31/33/53 to SP-OP-34 | | | | | | | | |
| 2E4S02 | No work Package assigned this WBS | | | | | | | | |
| 2E4S03 | No work Package assigned this WBS | | | | | | | | |
| 2E4S04 | SP-CS-33 | | | | | | c | | |
| 2E4S05 | No work Package assigned this WBS | | | | | | | | |
| 2E4S06 | No work Package assigned this WBS | | | | | | | | |
| 2E4S07 | Completed 1990 SP-CS-62/33 32 to SP-OP-35 | Nov-90 | | | | | c | | |
| | | | | | | | | | |
| | HIGHWALL RECLAMATION | | | | | | | | |
| | | | | | | | | | |
| 2E5J01 | Trim JP Highwalls | | | | | | | | |
| 2E5J02 | Scale JP Highwalls | | | | | | | | |
| 2E5N01 | Scale N. Paguate Highwalls | Dec-91 | | | | | | | |
| 2E5N02 | Trim N. Paguate Highwalls | Dec-91 | | | | | | | |
| 2E5S01 | Scale S. paguate Highwalls | Dec-91 | | | | | | | |
| 2E5S02 | Trim S. Paguate Highwalls | Dec-91 | | | | | | | |
| | | | | | | | | | |
| | EROSION CONTROL | | | | | | | | |
| | | | | | | | | | |
| 2E6N01A | Rio Moquino Erosion Control | Nov-94 | | | | | | | |
| 2E6N02 | Delete Rio Moquino Channel | | | | | | | | |
| 2E6N03 | Deleted 1990 Bedding Material | | | | | | | | |
| | | | | | | | | | |
| 2E6X01 | Deleted 1990 Quarry Rock | | | | | | | | |
| 2E6X02 | Deleted 1990 Process Rock | | | | | | | | |
| | | | | | | | | | |
| 2R1N01 | Reseed N P Flat Areas | Nov-94 | | | | | | | |
| 2R1N02 | Reseed N P Slope Areas | Nov-94 | | | | | | | |
| | | | | | | | | | |
| | UNDERGROUND ENTRIES ABANDONMENT | | | | | | | | |
| | | | | | | | | | |
| 2S1J01 | Seal JP-SS-50 Entries | | | | | | | | |
| 2S1J02 | Seal JP-PS-46 Entries | | | | | | | | |
| 2S1N01 | Seal PW-2/3 Adit | Feb-90 | | | | | | | |
| 2S1S01 | Seal P-13 Adit | Dec-91 | | | | | | | |
| 2S1S02 | P-10 Decline Closure | Feb-92 | | | | | | | |
| 2S1S03 | Seal H-1 Adit | Feb-90 | | | | | | | |
| 2S1S04 | Seal Vent Holes | Feb-92 | | | | | | | |
| 2S1S05 | Plug Drill Holes | Feb-90 | | | | | | | |
| | | | | | | | | | |
| | PIT WATER | | | | | | | | |
| | | | | | | | | | |
| 2S2J01 | Dewater Jackpile Pit PY-91 92 93 | Dec-91 | | | | | | | |
| 2S2N01 | Dewater No. Paguate Pit | Jul-90 | | | | | | | |
| 2S2S01 | Dewater So. Paguate Pit | Nov-90 | | | | | | | |

05000106

| Used Marvin's Closeout Summary Table and Added entries from Monthly Report "Detail for PTD" | | Marvin's Closeout Dates | Coded for Various Pile Categories | | | | | ROD Categories | Relate Draft EIS Piles to Work Units |
|---|---|---|---|---|---|---|---|---|---|
| | | | Protore | Waste | Shale | Topsoil | Contam. | | EIS Protore, Waste & Topsoil Piles |
| | SURFACE STRUCTURE DEMOLITION | | | | | | | | |
| 2S3J01 | Demolish Jackpile Surface Structures | | | | | | | | |
| 2S3N01 | Demolish No. Paguate Structures | Feb-90 | | | | | | | |
| 2S3S01 | Demolish South Paguate Surface Structures | | | | | | | | |
| 2S4XY | Not Assigned | | | | | | | | |
| | PERMANENT STRUCTURE | | | | | | | | |
| 2S5J01 | Construct Permanent Access Roads JP | | | | | | | | |
| 2S5J02A | Rio Moquino Drop Structure | | | | | | | | |
| 2S5J02 | Construct Fences-Jackpile Area | Dec-91 | | | | | | 1D | |
| 2S5N01 | Constr. Permanent Access Roads NP | | | | | | | | |
| 2S5N02 | Construct Fences-N. paguate Area | Dec-91 | | | | | | 1D | |
| 2S5S01 | Constr. Permanent Access Roads SP | | | | | | | | |
| 2S5S02 | Construct Fences-S. paguate Area | Dec-91 | | | | | | 1D | |
| 2S5J09 | Constr. Perm Fences All Areas | | | | | | | | |
| | SEED BEDS | | | | | | | | |
| 2R1J01 | Prepare Bed and Seed JP Flat Areas | | | | | | | | |
| 2R1J02 | Prepared Bed and Seed JP Slope Areas | | | | | | | | |
| 2R1N01 | Prepare Bed and Seed NP Flat Areas | | | | | | | | |
| 2R1N02 | Prepared Bed and Seed NP Slope Areas | | | | | | | | |
| 2R1S01 | Prepare Bed and Seed SP Flat Areas | | | | | | | | |
| 2R1S02 | Prepared Bed and Seed SP Slope Areas | | | | | | | | |
| 2R1S03 | Complete 1990 Reseed and Housing Area | | | | | | | | |
| | IRRIGATION | | | | | | | | |
| 2R2J01 | Deleted 1990 Irrigation | | | | | | | | |
| 2R2N01 | Deleted 1990 Irrigation | | | | | | | | |
| 2R2S01 | Tree Planting | | | | | | | | |
| | BENCHES/TERRACING | | | | | | | | |
| 2T2J01 | JP-WS-01 Slopes | Jul-94 | | | | | | | Slope FD-2 |
| 2T2J02 | | | | | | | | | |
| 2T2J03 | Cut JP-WO-03A /3B/4A/4B Slopes | | | | | | | | Slope X,I,Y,Y2 |
| 2T2N01 | Cut NP-WO-01 Rio Moquino Benches | Sep-92 | | | | | | | |
| 2T2S01 | Cut SP-SW-06 Slopes Oak Canyon | | | | | | | | |
| 2T2PLR | Misc Repairs PY 93 Force Account | | | | | | | | |
| 2T1J01 | Terracing JP Area 29000 lf | | | | | | | | |
| 2T1N01 | Terracing NP Area 1200 lf | | | | | | | | |
| 2T1S01 | Terracing SP Area 19100 lf | | | | | | | | |

# TABLE A-4 Work Packages vs. Monthly Report Activities

From Monthly Reports
C = Closeouts from Section 5.3

MONTHLY REPORTS A=Activity (Section 5.2) C=Field Completion (Section 5.3 Item 2) S=Suspended Activity (Section 5.2)

Month: 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6

Year: 89 89 89 89 89 90 90 90 90 90 90 90 90 90 90 90 90 91 91 91 91 91 91 91 91 91 91 91 91 92 92 92 92 92 92 92 92 92 92 92 92 93 93 93 93 93 93 93 93 93 93 93 93 94 94 94 94 94 94 94 94 94 94 94 94 95 95 95 95 95 95

Report Number: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71

| Activity in Work Units Based on Monthly Reports | | Completion Dates | From Monthly Reports | | | From Monthly Reports (Report Number: mark) |
|---|---|---|---|---|---|---|
| Work Unit Description. | | Marvin's Table | Construction Report | | | |
| | | Completion Dates | Vol. | Completion Date | POL Signature Certified | |
| | BACKFILLING = Moving Waste and Protore to Open Pits | | | | | |
| Jackpile | J = Jackpile | | | | | 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 |
| 2E1J01/01B | Haul Roads and Ramps thru PY93 | | | | | 22 A, 23 A, 24 A, 25 A, 26 A, 27 A, 28 A, 29 A, 30 A, 41 A, 42 A, 70 A, 71 A |
| 2E1J02 | JP-PS-23 to Backfill (JP-OP-41) | Dec-92 | | | | 41 C, 42 A |
| 2E1J03 | JP-PS-24 Pit Backfill (JP-OP-41) | Apr-93 | | | | 33 A, 34 A, 35 A, 36 A, 37 A, 38 A, 39 A, 41 S, 42 A, 43 A, 44 C, 45 C |
| 2E1J04 | JP-PS-25 Pit Backfill (JP-OP-41) | Apr-93 | | | | 34 A, 35 A, 36 A, 37 A, 38 A, 39 A, 41 A, 42 A, 43 A, 44 C, 45 C |
| 2E1J05 | Pit Backfill JP-PS-26 (JP-OP-41) | Feb-92 | | | | 28 A, 29 A, 30 C, 31 C, 32 C |
| 2E1J06 | Pit Backfill JP-WO-10 (JP-OP-41) | Feb-92 | | | | 30 A, 31 C, 32 C |
| 2E1J07 | JP-PS-27 to Backfill (JP-OP-41) | Dec-92 | | | | 30 S, 31 S, 32 S, 33 S, 34 S, 35 A, 36 A, 37 A, 38 C, 41 C |
| 2E1J08 | JP-WO-07 Pit Backfill (JP-OP-41) | Apr-93 | | | | 31 A, 32 A, 33 A, 34 A |
| 2E1J09 | JP-WO-12 to Pit Backfill (JP-OP-41) | Jul-94 | | | | 47 A, 48 A, 49 A, 50 A, 51 A, 53 A, 55 A, 60 C |
| 2E1J10 | JP-WS-08 to JP-OP-41 | Not Used | | | | |
| 2E1J11 | JP-WS-15 Pit Backfill (JP-OP-41) | Nov-94 | | | | 59 A, 60 A, 61 A, 62 A, 63 A, 64 C, 65 C |
| 2E1J12 | JP-WO-71 Pit Backfill (JP-OP-41) | Sep-93 | | | | 44 A, 46 A, 50 C |
| 2E1J13 | JP-WO-03 Pit Backfill (JP-OP-41) | Feb-92 | | | | 30 A, 31 A, 34 C |
| 2E1J14 | JP-WS-13 & WO-20 Backfill (JP-OP-42) | Dec-92 | | | | 39 A, 41 C |
| 2E1J15 | Jackpile Haul Roads- Force Account | NA | | | | |
| North Paguate | N=North Paguate | | | | | 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 |
| 2E1N01 | Build No Paguate Haul Roads | Nov-90 | 1.0 | 11-Apr-91 | Olsen | 21 $\boxed{\ }$ |
| 2E1N02 | Haul toPit NP-PS-17 | Sep-91 | 1.0 | 4-Sep-91 | Olsen | 10 A, 11 A, 12 S, 13 S, 14 S, 15 A, 16 A, 17 A, 18 A, 19 A, 26 $\boxed{C}$ |
| 2E1N03 | NP-PS-18 to No.Paguate Pit | Nov-90 | 1.0 | 11-Apr-91 | Harrison | 10 A, 11 A, 12 A, 13 A, 14 A, 15 A, 16 C, 17 A, 18 C, 21 $\boxed{C}$ |
| 2E1N04 | Haul NP-PS-14 to Pit | Feb-90 | 1.0 | 11-Apr-91 | Harrison | 6 A, 7 C, 8 A, 9 S, 10 S, 11 S, 12 S, 13 S, 14 S, 15 A, 16 S, 17 A, 18 C, 21 $\boxed{C}$ |
| 2E1N05 | NP-PS-15 to No.Paguate Pit | Nov-90 | 1.0 | 11-Apr-91 | Harrison | 8 S, 9 S, 10 S, 11 S, 12 S, 13 S, 14 S, 15 A, 16 C, 17 A, 18 C, 21 $\boxed{C}$ |
| 2E1N06 | NP-PS-16 to No. Paguate Pit | Nov-90 | 1.0 | 11-Apr-91 | Harrison | 10 A, 11 A, 12 A, 13 A, 14 A, 15 A, 16 C, 17 A, 18 C, 21 $\boxed{C}$ |
| 2E1N07 | SP-PS-01 to No. Paguate Pit | Nov-90 | 1.0 | 11-Apr-91 | Harrison | 5 A, 7 A, 8 A, 9 A, 10 A, 11 A, 12 A, 13 A, 14 A, 15 A, 16 C, 17 A, 18 C, 21 $\boxed{C}$ |
| 2E1N08 | No Work Unit Assigned this WBS | Not Used | | | | |
| 2E1N09 | No Work Unit Assigned this WBS | Not Used | | | | |
| 2E1N10 | NP-WT-10 Pit Backfill | Sep-91 | 1.0 | 4-Sep-91 | Olsen | 7 A, 8 A, 9 A, 10 A, 11 A, 12 A, 13 A, 14 A, 15 A, 16 A, 17 A, 18 A, 26 $\boxed{C}$ |
| 2E1N11 | Relocate NP-PS-13 to Pit | Feb-90 | 1.0 | 11-Apr-91 | Harrison | 4 A, 5 A, 6 S, 7 C, 8 S, 9 S, 10 S, 11 S, 12 S, 13 S, 14 S, 15 S, 16 S, 17 A, 18 C, 21 $\boxed{C}$ |
| 2E1N12 | Cut Slopes NP-OP-19 | Feb-90 | 1.0 | 4-Jul-90 | Harrison | 4 A, 5 A, 6 C, 7 C, 12 $\boxed{\ }$ |
| South Paguate | S=South Paguate | | | | | 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 |
| 2E1S01 | Construct SP Haul Roads | | | | | 14 A, 15 A, 16 A, 17 A, 18 A, 19 A, 20 A, 22 A |
| 2E1S02 | Pit Backfill SP-PS-02 | Sep-91 | 1.0 | 4-Sep-91 | Olsen | 21 A, 22 A, 26 $\boxed{C}$ |
| 2E1S03 | SP-PS-02 Additional Volume | Dec-91 | 1.0 | 16-Dec-91 | Olsen | 22 A, 26 C, 29 $\boxed{C}$ |
| | DUMP SLOPING | | | | | |
| Jackpile | J = Jackpile | | | | | 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 |
| 2E2J01 | JP-WO-11 Backfill | Jul-94 | | | | 29 A, 30 A, 31 A, 32 A, 33 A, 57 A, 58 C, 60 C |
| 2E2J02 | JP-WT-16 Backfill | Jul-94 | | | | 39 A, 55 A, 56 A, 57 A, 58 A, 59 A, 60 C |
| 2E2J03 | JP-WS-17 to Backfill (Dozers) | Dec-92 | | | | 32 A, 33 A, 34 A, 35 A, 41 C |
| 2E2J03A | JP-WS-17 Backfill | | | | | 60 A, 61 A, 62 A, 63 A, 64 A, 65 A, 66 A, 67 A, 68 A, 69 C, 70 C, 71 C |
| 2E2J04 | JP-PS-22 Cut Slopes | Dec-92 | | | | 41 C |
| 2E2J05 | Cut JP-WO-72 Slopes | Sep-92 | | | | 2 P, 36 A, 37 A |
| 2E2J06 | No Work Unit Assigned this WBS | Not Used | | | | |
| 2E2J07 | No Work Unit Assigned this WBS | Not Used | | | | |
| 2E2J08 | Cut JP-WS-01 Slopes | NC | | | | |
| 2E2J09 | Deleted (JP-WT-02A/02B/02C) | Not Used | | | | |
| 2E2J10 | JP-WO-73 Pit Backfill | Sep-93 | | | | 50 C |
| 2E2J11 | No Work Unit Assigned this WBS | | | | | |
| 2E2J12 | JP-WO-06 Cut Slopes | Apr-93 | | | | 43 A, 45 C, 50 C |
| 2E2J12 | JP-WO-06 Cut Slopes | Sep-93 | | | | 43 A, 45 C, 50 C |
| 2E2J13 | JP-WO-08 / WO-12 Cut Slopes | Apr-93 | | | | 32 A, 33 A, 38 A, 39 A, 41 A, 42 C, 45 C, 60 C |
| 2E2J14 | JP-WO-11 Cut Slopes | Feb-92 | | | | 16 A, 17 A, 18 A, 19 A, 20 A, 21 A, 22 A, 23 S, 24 S, 25 S, 26 S, 27 S, 28 S, 29 S, 30 S, 31 S, 32 A, 34 C |
| 2E2J15 | Cut Slopes JP-WS-15 (15A/15B Slopes) | Sep-91 | 1.0 | 9-Apr-91 | Olsen | 17 A, 18 A, 21 $\boxed{\ }$, 26 C |
| 2E2J16 | JP-WO-05 Cut Slopes | Apr-93 | | | | 42 A, 43 A, 44 A, 45 C, 60 C |
| 2E2J17 | Cut JP-WT-16A/16B/16C/Slopes | NC | | | | |
| 2E2J18 | Shale to JP-D4 | | | | | |

| Activity in Work Units Based on Monthly Reports | | Completion Dates | From Monthly Reports | | | From Monthly Reports C = Closeouts from Section 5.3 |
|---|---|---|---|---|---|---|
| Work Unit Description. | | Marvin's Table | Construction Report | | | MONTHLY REPORTS A=Activity (Section 5.2) C=Field Completion (Section 5.3 Item 2) S=Suspended Activity (Section 5.2) |
| | | Completion Dates | Vol. | Completion Date | POL Signature Certified | Report Number: 1–71 (Month/Year: 8/89 – 6/95) |
| 2E2J19 | JP-WO-73 Pit Backfill | Apr-93 | | | | 41 A, 42 A, 43 A, 44 C, 45 C |
| 2E2J20 | Cut Slope JP-WO-14 | Dec-91 | 1.0 | 16-Dec-91 | Olsen | 28 C, 29 [C] |
| 2E2J21 | JP-WS-15A Cut Slopes | Feb-92 | | | | 29 A, 30 A, 31 A, 32 C, 34 C |
| 2E2J22 | JP-WS-19 B & C | Sep-92 | | | | 27 A, 31 A, 32 C, 38 C |
| 2E2J23 | Cut JP-WS-19C Slopes | | | | | 23 A, 24 A, 27 A, 31 A, 32 C, 43 A, 45 C |
| 2E2J24 | Cut Slopes JP-WO-66 | Sep-91 | | | | 22 A, 23 A, 24 A, 25 A, 26 S, 27 S, 28 S, 29 A, 30 C |
| 2E2J25 | Deleted (JP-WO-70) | | | | | |
| 2E2J26 | JP-WO-18A / 66A Cut Slopes | Dec-92 | | | | 41 C |
| 2E2J27 | Cut Slopes JP-WO-18B & 66C | Sep-92 | | | | 22 A, 23 A, 38 C |
| 2E2J28 | JP-WO-18C / 66C | Dec-92 | | | | 36 A, 37 A, 38 C, 41 C |
| 2E2J29 | JP-WO-03A Cut Slopes | Jul-94 | | | | 46 A, 47 A, 49 S, 50 A, 60 C |
| 2E2J30 | JP-WO-03B Cut Slopes | Sep-93 | | | | 45 A, 46 A, 47 A, 50 C |
| 2E2J31 | JP-WO-04A Cut Slopes | Sep-93 | | | | 43 A, 44 A, 45 A, 46 A, 47 C, 50 C |
| 2E2J32 | JP-WO-04B Cut Slopes | Sep-93 | | | | 45 A, 50 C |
| North Paguate | N=North Paguate | | | | | 1–71 |
| 2E2N01 | Cut Bench NP-WO-01 | Feb-92 | | | | 34 A, 38 C |
| 2E2N02 | Cut Slopes NP-WO-02 | Sep-91 | 1.0 | 9-Apr-91 | Olsen | 20 A, 21 [A], 26 C |
| 2E2N03 | Cut Slopes N P- WS-03 | Sep-91 | 1.0 | 9-Apr-91 | Olsen | 18 A, 19 A, 20 A, 21 [A], 26 C |
| 2E2N04 | Slope NP-WO-04 | Nov-90 | 1.0 | 11-Apr-91 | Harrison | 8 S, 9 S, 10 S, 11 S, 12 S, 13 S, 14 S, 15 S, 16 C, 17 S, 18 C, 20 A, 21 [C] |
| 2E2N05 | Cut NP-WO-06 Slopes | NC | | | | 4 A, 5 A, 6 A, 7 A, 8 A, 9 A, 10 A, 11 A, 12 A, 13 A |
| 2E2N06 | Cut NP-WT-09 Slopes | NC | | | | |
| 2E2N07 | Regrade NP-DN-22 | Dec-91 | 1.0 | 16-Dec-91 | Olsen | 20 A, 29 [C] |
| 2E2N08 | Cut Slopes NP-WM-12 | Sep-91 | 1.0 | 4-Sep-91 | Olsen | 18 A, 19 A, 26 [C] |
| 2E2N09 | Slope NP-HW-25 | Nov-90 | 1.0 | 11-Apr-91 | Harrison | 7 A, 8 A, 9 A, 10 A, 11 A, 12 A, 16 C, 18 A, 19 A, 21 [C] |
| South Paguate | S=South Paguate | | | | | 1–71 |
| 2E2S01 | Slope SP-13A / WO-10 | Nov-90 | 1.0 | 11-Apr-91 | Harrison | 16 C, 18 C, 21 [C] |
| 2E2S02 | Cut Slopes SP-WS-17 | Dec-91 | 1.0 | 16-Dec-91 | Olsen | 6 A, 7 A, 8 A, 10 A, 11 A, 12 A, 13 A, 14 A, 15 A, 16 A, 17 A, 18 A, 22 A, 23 A, 24 A, 29 [C] |
| 2E2S03 | Cut Slope SP-WO-13B & WS-18A | Dec-91 | 1.0 | 16-Dec-91 | Olsen | 10 A, 11 A, 12 A, 13 A, 14 A, 15 A, 16 A, 17 A, 18 A, 19 A, 20 A, 21 A, 22 A, 23 A, 24 A, 29 [C] |
| 2E2S04 | Cut SP-WO-14 Slopes | Feb-90 | 1.0 | 11-Apr-91 | Harrison | 6 A, 7 C, 18 C, 21 [C] |
| 2E2S05 | Cut SP-WS-18B Slopes | NC | | | | 9 A |
| 2E2S06 | Slope SP-WS-18C / WT-19 | Nov-90 | 1.0 | 11-Apr-91 | Harrison | 12 A, 13 A, 14 A, 15 A, 16 C, 17 A, 18 C, 21 [C] |
| 2E2S07 | Slope SP-WT -03 | Nov-90 | 1.0 | 11-Apr-91 | Harrison | 12 A, 13 A, 14 A, 15 A, 16 C, 18 C, 21 [C] |
| 2E2S08A | SP-OP-34 Backfill (Force Account) SP-WT-06 | NC | | | | |
| 2E2S09 | Cut SP-WO-38 Slopes | Feb-90 | 1.0 | 11-Apr-91 | Harrison | 6 A, 7 C, 18 C, 21 [C] |
| 2E2S10 | SP-WS-06 | Deleted | | | | |
| 2E2S11 | Slope SP-WT-19A | Nov-90 | 1.0 | 11-Apr-91 | Harrison | 10 A, 11 A, 12 A, 13 A, 14 A, 15 A, 16 C, 18 C, 21 [C] |
| 2E2S12 | Slope WS-WM-12 | Nov-90 | 1.0 | 11-Apr-91 | Harrison | 10 A, 11 A, 12 A, 13 A, 14 A, 15 A, 16 C, 18 C, 21 [C] |
| 2E2S13 | SP-WT-15A,B | Deleted | | | | |
| 2E2S14 | Backfill SP-OP-34 (D4-West) | Dec-91 | 1.0 | 16-Dec-91 | Olsen | 25 C, 29 [C] |
| 2E2S15 | Slope SP-WT -16/37 | Nov-90 | 1.0 | 11-Apr-91 | Harrison | 15 A, 16 C, 18 C, 21 [C] |
| 2E2S16 | Backfill SP-OP-34 (D4-East) | Dec-91 | 1.0 | 16-Dec-91 | Olsen | 29 [C] |
| 2E2S17 | Backfill SP-OP-34 (SP-14) | Dec-91 | 1.0 | 16-Dec-91 | Olsen | 29 [C] |
| 2E2S18 | Backfill SP-OP-34(Sh-2) | Dec-91 | 1.0 | 16-Dec-91 | Olsen | 29 [C] |
| 2E2S19 | Misc. So. Paguate Sloping | Nov-90 | 1.0 | 11-Apr-91 | Harrison | 16 C, 18 C, 21 [C] |
| | COVER PLACEMENT | | | | | |
| Jackpile | J = Jackpile | | | | | 1–71 |
| 2E3J01 | Haul Soil from JP-SB-53 to D4 Soil Cover | Apr-93 | | | | 36 A, 39 A, 45 C |
| 2E3J02 | Haul Soil from JP-SB-53 to D5 Soil Cover | Apr-93 | | | | 39 A, 45 C |
| 2E3J03 | Haul Soil from JP-SB-53 to D6 Soil Cover | | | | | 57 A, 58 C, 67 A, 68 A, 69 A, 70 C, 71 C |
| 2E3J04 | Haul Soil from JP-SB-53 to D9A | Jul-94 | | | | 57 A, 59 A, 60 C |
| 2E3J05 | Haul Soil from JP-SB-53 to D1 | Nov-94 | | | | 49 A, 50 A, 52 A, 54 A, 55 A, 56 A, 57 A, 58 A, 64 C, 65 C |
| 2E3J06 | Haul Soil from JP-SB-53 to D3 | | | | | 60 A, 61 A, 62 A, 63 A, 64 A, 65 A, 66 A, 67 A, 68 A, 69 A, 70 C, 71 C |
| 2E3J07 | Haul Soil from JP-SB-53 to D2 | | | | | 55 A, 56 A, 57 A |
| 2E3J08 | Haul Soil from JP-SB-64 to D7 | | | | | 46 A, 52 A, 59 A |
| 2E3J08A | JP-WO-07 Pit Backfill | Sep-93 | | | | 43 A, 44 A, 45 A, 46 A, 47 A, 50 C |
| 2E3J09 | Haul Soil from JP-SB-64 to D11 | Nov-94 | | | | 46 A, 54 A, 64 C, 65 C |
| 2E3J10 | Haul Soil from JP-SB-64 to D12 or D12A | Sep-93 | | | | 44 A, 45 A, 47 A, 50 C |
| 2E3J11 | Haul Soil from JP-SB-54 to D16 | Sep-93 | | | | 45 A, 47 A, 50 C, 52 A |
| 2E3J12 | Haul Soil from JP-SB-54 to D15 | Jul-94 | | | | 49 A, 50 C, 60 C |
| 2E3J12 | Soil JP-D15 | Sep-93 | | | | 49 A, 50 C, 60 C |
| 2E3J13 | Soil to JP-D4 | Jul-94 | | | | 49 A, 50 A, 51 A |
| 2E3J14 | 1990 (JP-SB-54) | Deleted | | | | 51 A |
| 2E3J15 | Topsoil to H-1 mine area | Dec-91 | 1.0 | 16-Dec-91 | Olsen | 28 C, 29 [C] |
| 2E3J16 | Soil to JP-D13 | Jul-94 | | | | 51 A, 52 A |
| 2E3J17 | Soil JP-D8B | | | | | 60 A, 61 A, 62 A, 63 A, 64 A, 65 A, 66 A, 67 A, 68 A, 69 A, 70 C, 71 C |
| 2E3J18 | Haul Shale from JP-WS-19 to D4 | NC | | | | |

| Activity in Work Units Based on Monthly Reports | | Completion Dates | From Monthly Reports | | | From Monthly Reports C = Closeouts from Section 5.3 |
|---|---|---|---|---|---|---|
| | | | | | | MONTHLY REPORTS A=Activity (Section 5.2) C=Field Completion (Section 5.3 Item 2) S=Suspended Activity (Section 5.2) |
| Work Unit Description. | | Marvin's Table | Construction Report | | | Month / Year: 8/89 – 6/95; Report Number 1–71 |
| | | Completion Dates | Vol. | Completion Date | POL Signature Certified | |
| 2E3J19 | Haul Shale from JP-WS-15 to D1 | NC | | | | |
| 2E3J20 | Haul Shale from JP-WS-15 to D2 Shale Cover | Apr-93 | | | | |
| 2E3J21 | Haul Shale from JP-WS-15 to D7 | NC | | | | |
| 2E3J22 | Haul Shale from JP-WS-15 to D11 | NC | | | | S A A A A A |
| 2E3J23 | Haul Shale from JP-WS-15 to D12 | Apr-93 | | | | A A A A A |
| 2E3J23 | Shale JP-D15 | Sep-93 | | | | A A A |
| 2E3J24 | Haul Shale from JP-WT-02 TO D8A | Nov-94 | | | | A A A A A A A C |
| 2E3J24 | JP-WO-02 | NC | | | | A A A A A A A C |
| 2E3J25 | | | | | | |
| 2E3J26 | Shale Cover JP-D13 | Jul-94 | | | | A A |
| 2E3J27 | Shale JP-D14 or D4 | Sep-93 | | | | C |
| 2E3J28 | Haul Shale from JP-WT-02 to D15 | Jul-94 | | | | C A |
| 2E3J29 | Haul Shale from JP-WT-02 to D16 | Sep-93 | | | | A A C |
| North Paguate | N=North Paguate | | | | | 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 |
| 2E3N01 | Haul Soil from NP-SB-61 to NP-D8 | Sep-92 | | | | C C |
| 2E3N02 | Haul Soil from NP-SB-26 to NP-D2 | Sep-91 | 1.0 | 04-Sep-91 | Olsen | A C C |
| 2E3N02 | Soil Cover NP-D7 | Sep-92 | | | | A C C |
| 2E3N03 | Haul Soil from NP-SB-27 to NP-D7 | NC | | | | A C A |
| 2E3N04 | Haul Soil from NP-SB-27 to D9 | Feb-92 | | | | A C C C A |
| 2E3N05 | Haul Soil from NP-SB-27 to D6 | Dec-92 | | | | A C |
| 2E3N06 | Haul Soil from NP-SB-61 to NP-D9 | Feb-92 | | | | C C |
| 2E3N07 Topsoil | Haul Soil from SP-DN-61 to NP-D4 | Nov-91 | 1.0 | 13-Nov-91 | Olsen | A A C |
| 2E3N07 Shale | Haul Soil from SP-DN-61 to NP-D4 | | 1.0 | 16-Dec-91 | Olsen | A A |
| 2E3N08 Topsoil | Haul Soil from SP-DN-61 to NP-D1 | Nov-91 | 1.0 | 13-Nov-91 | Olsen | A C |
| 2E3N08 Shale | Haul Soil from SP-DN-61 to NP-D1 | | 1.0 | 16-Dec-91 | Olsen | A C |
| 2E3N09 | Haul Soil from SP-DN-61 to NP-D3 | Sep-91 | 1.0 | 4-Sep-91 | Olsen | A A A C C |
| 2E3N10 | Haul Soil from SP-DN-61 to NP-D5 | Sep-91 | 1.0 | 4-Sep-91 | Olsen | A A A |
| 2E3N11 | Haul Soil from SP-DN-61 to NP-D10 | Sep-92 | | | | A C |
| 2E3N12 | Soil to NP-D6 (Benches) | Sep-92 | | | | A A C |
| 2E3N13 | Haul Shale Cover From NP-WS-31 to N P-D9 | Feb-92 | | | | A A S S S S S C C |
| 2E3N14 | Shale Borrow to N P-D4 | Sep-91 | 1.0 | 9-Apr-91 | Olsen | A A C |
| 2E3N15 | Shale Borrow to NP-D5 | Sep-91 | 1.0 | 4-Sep-91 | Olsen | A A |
| 2E3N16 | Haul Shale from NP-WS-31 to NP-D8 | Feb-92 | | | | A C C |
| 2E3N16 | Shale Cover NP-D8 | Sep-92 | | | | A C C |
| 2E3N17 | Haul Shale from NP-WS-31 to NP-D10 | Sep-92 | | | | A C |
| 2E3N18 | Haul Shale From NP-WS-03 to NP-D3 | Sep-91 | 1.0 | 4-Sep-91 | Olsen | A A A |
| 2E3N19 | Haul Shale From NP-WS-03 to NP-D3 | Sep-91 | 1.0 | 14-Sep-91 | Olsen | A A |
| 2E3N20 | No Work Package Assigned this WBS# | | | | | |
| 2E3N21 | Haul Shale from NP-WS-03 to NP-D1 | NC | | | | |
| South Paguate | S=South Paguate | | | | | 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 |
| 2E3S01 | Topsoil Soil Borrow SP-OP-35 (SP-D1) from SP-SB | Sep-91 | | | | A A C |
| 2E3S02 | Topsoil Soil Borrow SP=WS-17(SP-D2) from SP-SB | Dec-91 | 1.0 | 16-Dec-91 | Olsen | A A C |
| 2E3S03 | Topsoil Soil Borrow to SP-D3 from SP-SB-44 | Dec-91 | 1.0 | 16-Dec-91 | Olsen | A A A A |
| 2E3S04 | Haul Soil from SP-SB-42 to SP-D4 | Feb-92 | | | | A A C C |
| 2E3S05 | Haul Soil from SP-SB-42 to SP-D5 | Feb-92 | | | | A C C |
| 2E3S06 | Haul Soil from SP-SB-42 to SP-D6 | Feb-92 | | | | A C C C |
| 2E3S07 | Haul Soil from SP-SB-42 to SP-D7 | Feb-92 | | | | A A A A A A A A C C C |
| 2E3S08 | Topsoil to SP-D8 from SP-SB-44 | Dec-91 | 1.0 | 16-Dec-91 | Olsen | A A C C |
| 2E3S09 | Topsoil to SP-D9 from SP-SB-42 | Dec-91 | 1.0 | 16-Dec-91 | Olsen | A A A A A A A A C |
| 2E3S10 | Haul Soil fom SP-SB-42 to SP-D10 | Not Used | | | | |
| 2E3S11 | Topsoil to SP-D11 from SP-SB-42 | Dec-91 | 1.0 | 16-Dec-91 | Olsen | A A A A C |
| 2E3S12 | Soil Cover to SP-D12 from SP-SB-43 | Feb-92 | | | | A C |
| 2E3S13 | Topsoil to SP-D1B from SP-SB-50 | Nov-91 | 1.0 | 13-Nov-91 | Olsen | A A C |
| 2E3S14 | Shale Cover SP-WO-13A from SP-WS-17 | Sep-91 | | | | A A C C |
| 2E3S15 | Shale Borrow (SP-13B) from SP-WS-15 | Not Used | | | | |
| 2E3S16 | Shale Borrow for SP-PS-01 from SP-WS-07 | Sep-91 | 1.0 | 9-Apr-91 | Olsen | A C |
| 2E3S17 | Shale Cover to SP-14 from SP-WS-07 | Dec-91 | 1.0 | 16-Dec-91 | Olsen | C |
| 2E3S18 | Haul Shale Borrow from SP-WS-07 to SP-WO-04 | Sep-91 | 1.0 | 9-Apr-91 | Olsen | A A |
| 2E3S19 | Haul Shale from Sp-WS-07 to SP-D10 | Nov-91 | 1.0 | 13-Nov-91 | Olsen | A C |
| 2E3S20 | Haul Shale to SP-38 Shale from SP-WS-07 | Sep-91 | 1.0 | 4-Sep-91 | Olsen | A A |
| 2E3S21 | Haul Shale Cover from SP-WS-07 to SP- WO-10 | Sep-91 | | | | A A A C |
| | CONTAMINATED SOIL EXCAVATION | | | | | |
| Jackpile | J = Jackpile | | | | | 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 |
| 2E4J01 | HaulJP-CS-36 to JP-OP-41 for Backfill | Feb-92 | | | | C |
| 2E4J02 | Haul JP-CS-37/38 to JP-OP-41 Backfill | Dec-92 | | | | |
| 2E4J03 | No work Package assigned this WBS | | | | | |
| 2E4J04 | Combined into 2E4J02 | | | | | |

| Activity in Work Units Based on Monthly Reports | | Completion Dates | From Monthly Reports | | | From Monthly Reports C = Closeouts from Section 5.3 |
|---|---|---|---|---|---|---|
| Work Unit Description. | | Marvin's Table | Construction Report | | | MONTHLY REPORTS A=Activity (Section 5.2) C=Field Completion (Section 5.3 Item 2) S=Suspended Activity (Section 5.2) |
| | | Completion Dates | Vol. | Completion Date | POL Signature Certified | Month 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6; Year 89 89 89 89 89 90 90 90 90 90 90 90 90 90 90 90 90 91 91 91 91 91 91 91 91 91 91 91 91 92 92 92 92 92 92 92 92 92 92 92 92 93 93 93 93 93 93 93 93 93 93 93 93 94 94 94 94 94 94 94 94 94 94 94 94 95 95 95 95 95 95; Report Number 1–71 |
| North Paguate | N=North Paguate | | | | | |
| 2E4N01 | Haul Pit Backfill from NP-CS-24/23 to NP-OP-20 | Sep-91 | | | | 19–25: A; 30: C |
| 2E4N01 A | N. Rio Paguate Backfill-East | Dec-91 | 1.0 | 16-Dec-91 | Olsen | 19–25: A; 29: [C] |
| 2E4N01 B | N. Rio Paguate Backfill-West | Dec-91 | 1.0 | 16-Dec-91 | Olsen | 19–25: A; 29: [C] |
| South Paguate | S=South Paguate | | | | | |
| 2E4S01 | SP-SS-27/28, CS | NC | | | | 3–5: A; 7–20: A; 27–28: A |
| 2E4S01 | FM S-CS-27/28/31/33/53 to SP-OP-34 | | | | | 11–20: A; 27–28: A |
| 2E4S02 | No work Package assigned this WBS | | | | | |
| 2E4S03 | No work Package assigned this WBS | | | | | |
| 2E4S04 | SP-CS-33 | | | | | |
| 2E4S05 | No work Package assigned this WBS | | | | | |
| 2E4S06 | No work Package assigned this WBS | | | | | |
| 2E4S07 | Completed 1990 SP-CS-62/33 32 to SP-OP-35 | Nov-90 | 1.0 | 11-Apr-91 | Harrison | 14: A; 15: A; 16: C; 17: A; 18: C; 21: [C] |
| | HIGHWALL RECLAMATION | | | | | |
| 2E5J01 | Trim JP Highwalls | | | | | |
| 2E5J02 | Scale JP Highwalls | | | | | |
| 2E5N01 | Scale N. Paguate Highwalls | Dec-91 | 1.0 | 16-Dec-91 | Olsen | 10–20: A; 21–22: S; 29: [ ] |
| 2E5N02 | Trim N. Paguate Highwalls | Dec-91 | 1.0 | 16-Dec-91 | Olsen | 10–20: A; 21–22: S; 29: [ ] |
| 2E5S01 | Scale S. paguate Highwalls | Dec-91 | 1.0 | 16-Dec-91 | Olsen | 10–12: A; 29: [C] |
| 2E5S02 | Trim S. Paguate Highwalls | Dec-91 | 1.0 | 16-Dec-91 | Olsen | 10–12: A; 29: [ ] |
| | EROSION CONTROL | | | | | |
| 2E6N01A | Rio Moquino Erosion Control | Nov-94 | | | | 43–44: A; 45–48: S; 50–55: A; 57: A; 64: C; 65: C |
| 2E6N02 | Delete Rio Moquino Channel | | | | | |
| 2E6N03 | Deleted 1990 Bedding Material | | | | | |
| 2E6X01 | Deleted 1990 Quarry Rock | | | | | |
| 2E6X02 | Deleted 1990 Process Rock | | | | | |
| | UNDERGROUND ENTRIES ABANDONMENT | | | | | |
| 2S1J01 | Seal JP-SS-50 Entries | | | | | |
| 2S1J02 | Seal JP-PS-46 Entries | | | | | |
| 2S1N01 | Seal PW-2/3 Adit | Feb-90 | 1.0 | 30-Mar-90 | Harrison | 4: A; 5: A; 6: C; 7: C; 8: [ ] |
| 2S1S01 | Seal P-13 Adit | Dec-91 | 1.0 | 16-Dec-91 | Olsen | 12: A; 19: S; 29: [ ] |
| 2S1S02 | P-10 Decline Closure | Feb-92 | | | | 10: A; 11–18: S; 20: S; 21: A; 22–26: S; 31: C; 32: C |
| 2S1S03 | Seal H-1 Adit | Feb-90 | 1.0 | 1-Feb-90 | Olsen | 4: A; 5: A; 6: C; 7: [ ] |
| 2S1S04 | Seal Vent Holes | Feb-92 | | | | 4: A; 5: A; 6–29: S; 30: C; 32: C |
| 2S1S05 | Plug Drill Holes | Feb-90 | 1.0 | 30-Mar-90 | Harrison | 3: A; 4: S; 5: A; 6: C; 7: C; 8: [ ] |
| | Pit Water | | | | | |
| 2S2J01 | Dewater Jackpile Pit PY-91 92 93 | Dec-91 | 1.0 | 16-Dec-91 | Olsen | 14: A; 27: A; 29: [A]; 30: A |
| 2S2N01 | Dewater No. Paguate Pit | Jul-90 | 1.0 | 20-Jun-90 | Harrison | 11: [ ] |
| 2S2S01 | Dewater So. Paguate Pit | Nov-90 | 1.0 | 11-Apr-91 | Harrison | 21: [C] |
| | Surface Structure Demolition | | | | | |
| 2S3J01 | Demolish Jackpile Surface Structures | | | | | 7–13: A; 14: S; 15–17: A |
| 2S3N01 | Demolish No. Paguate Structures | Feb-90 | 1.0 | 20-Jun-90 | Harrison | 3: A; 4: S; 5: A; 6: C; 7: C; 11: [ ]; 21: C |
| 2S3S01 | Demolish South Paguate Surface Structures | | | | | 1–6: A; 7–11: S; 12–13: A; 14–20: S; 21: A; 22–25: S; 26–27: A |
| 2S4XY | Not Assigned | | | | | |
| | Permanent Structure | | | | | |
| 2S5J01 | Construct Permanent Access Roads JP | | | | | |
| 2S5J02A | Rio Moquino Drop Structure | | | | | |
| 2S5J02 | Construct Fences-Jackpile Area | Dec-91 | 1.0 | 16-Dec-91 | Olsen | 29: [C] |
| 2S5N01 | Constr. Permanent Access Roads NP | | | | | |
| 2S5N02 | Construct Fences-N. paguate Area | Dec-91 | 1.0 | 16-Dec-91 | Olsen | 11–16: A; 29: [C] |
| 2S5S01 | Constr. Permanent Access Roads SP | | | | | |
| 2S5S02 | Construct Fences-S. paguate Area | Dec-91 | 1.0 | 16-Dec-91 | Olsen | 29: [C] |
| 2S5J09 | Constr. Perm Fences All Areas | | | | | 19–26: A; 27–30: S; 31–38: A; 41–42: A; 70–71: A |
| 2S5S10 | Site fencing | | | | | 17–18: A |

| Activity in Work Units Based on Monthly Reports | | Completion Dates | From Monthly Reports | | |
|---|---|---|---|---|---|
| | Work Unit Description. | Marvin's Table | Construction Report | | |
| | | Completion Dates | Vol. | Completion Date | POL Signature Certified |
| | **Seed Beds** | | | | |
| 2R1J01 | Prepare Bed and Seed JP Flat Areas | | | | |
| 2R1J02 | Prepared Bed and Seed JP Slope Areas | | | | |
| 2R1N01 | Prepare Bed and Seed NP Flat Areas | | | | |
| 2R1N02 | Prepared Bed and Seed NP Slope Areas | | | | |
| 2R1S01 | Prepare Bed and Seed SP Flat Areas | | | | |
| 2R1S02 | Prepared Bed and Seed SP Slope Areas | | | | |
| 2R1S03 | Complete 1990 Reseed and Housing Area | | | | |
| | **Irrigation** | | | | |
| 2R2J01 | Deleted 1990 Irrigation | | | | |
| 2R2N01 | Deleted 1990 Irrigation | | | | |
| 2R2S01 | Tree Planting | | | | |
| | **BENCHES/Terracing** | | | | |
| 2T2J01 | JP-WS-01 Slopes | Jul-94 | | | |
| 2T2J02 | | | | | |
| 2T2J03 | Cutr JP-WO-03A /3B/4A/4B Slopes | | | | |
| 2T2N01 | Cut NP-Wo-01 Rio Moquino Benches | Sep-92 | | | |
| 2T2S01 | Cut SP-SW-06 Slopes Oak Canyon | | | | |
| 2T2PLR | Misc Repairs PY 93 Force Account | | | | |
| 2T1J01 | Terracing JP Area 29000 lf | | | | |
| 2T1N01 | Terracing NP Area 1200 lf | | | | |
| 2T1S01 | Terracing SP Area 19100 lf | | | | |

From Monthly Reports
C = Closeouts from Section 5.3

MONTHLY REPORTS A=Activity (Section 5.2) C=Field Completion (Section 5.3 Item 2) S=Suspended Activity (Section 5.2)

| Report Number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 |
| Year | 89 | 89 | 89 | 89 | 89 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 94 | 94 | 94 | 94 | 94 | 94 | 94 | 94 | 94 | 94 | 94 | 94 | 95 | 95 | 95 | 95 | 95 | 95 |
| Seed Beds | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2R1J01 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | A | S | S | S | S | S | | | | | | A | A | A | A | C | C | C | S | S |
| 2R1J02 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | A | S | S | S | S | S | | | | | | A | A | A | A | C | C | C | S | S |
| 2R1N01 | | | | | | | | | | | | | | | | | | | | | | | | | | | A | A | S | S | S | S | A | S | S | S | S | S | S | | S | S | | | | | | | | | A | C | | | | | | | | | | | | C | C | | | | | | |
| 2R1N02 | | | | | | | | | | | | | | | | | | | | | | | | | | | A | A | S | S | S | S | A | S | S | S | S | S | S | | S | S | | | | | | | | | A | C | | | | | | | | | | | | C | C | | | | | | |
| 2R1S01 | | | | | | | | | | | | | | | | | | | | | | | | | | | A | A | S | S | S | S | A | A | S | S | S | S | S | | S | S | | | | | | | | | A | C | | | | | | | | | | | | | | | | | | | |
| 2R1S02 | | | | | | | | | | | | | | | | | | | | | | | | | | | A | A | S | S | S | S | A | A | S | S | S | S | S | | S | S | | | | | | | | | A | | | | | | | | | | | | | | | | | | | | |
| 2R1S03 | | | | | | | | | | A | A | A | | | | A | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Irrigation | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 |
| 2R2J01 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2R2N01 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2R2S01 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BENCHES/Terracing | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 |
| 2T2J01 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | A | | A | A | A | A | A | A | A | | A | A | A | A | A | A | C | | | | |
| 2T2J02 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2T2J03 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2T2N01 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | A | A | A | A | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2T2S01 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2T2PLR | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2T1J01 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | A | A | | A | A | A | | | | | | | | | | | | | | |
| 2T1N01 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2T1S01 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | A | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

# APPENDIX B

# Photographic Documentation

**Photo B-1:** Permanent Pond in NP-OP-20 near MW 20 W OAS Photo August 2006

**Photo B-2:** North Side of Waste Pile "H" OAS Photo August 2006

**Photo B-3:** Waste Pile "J" - Sloped and Seeded OAS Photo August 2006

**Photo B-4:** Fencing Photo from Monthly Report No. 14, Figure 3

**Photo B-5:** SP-OP-34 SW Highwall, Naturally Sloughing OAS Photo, August 2006

**Photo B-6:** SP-OP-35 Highwall OAS Photo August 2006

**Photo B-7:** Jackpile Highwall along Gavilan Mesa OAS Photo, August 2006

**Photo B-8:** Photo from Monthly Report No. 14 Figure 6 Terrace and Berm after unusually large rainfall

**Photo B-9:** Berm in South Paguate Pit, holding water as designed OAS Photo August 2006

**Photo B-10:** Additional view of Berms in South Paguate Pit OAS Photo August 2006

**Photo B-11:** South End of "I" above Road OAS Photo August 2006

**Photo B-12:** Blowout in Pile "A" Lower Terrace OAS Photo August 2006

**Photo B-13:** Roadway Erosion East Side of Wastepile "I" OAS Photo August 2006

**Photo B14:** Location of former protore piles along the Rio Paguate OAS Photo August 2006

**Photo B-15:** Armored Toe of Pile "T" along the Rio Moquino. POL Archived Photo taken sometime after Armoring was completed (late 1994).

**Photo B-16:** Armored Toe of Pile "T" along the Rio Moquino, the former road area is almost completely eroded. OAS Photo August 2007

**Photo B-17:** Rip Rapped Toe of Pile "N" and "N2" along the Rio Moquino, Close up of Erosion of most of the former roadway.

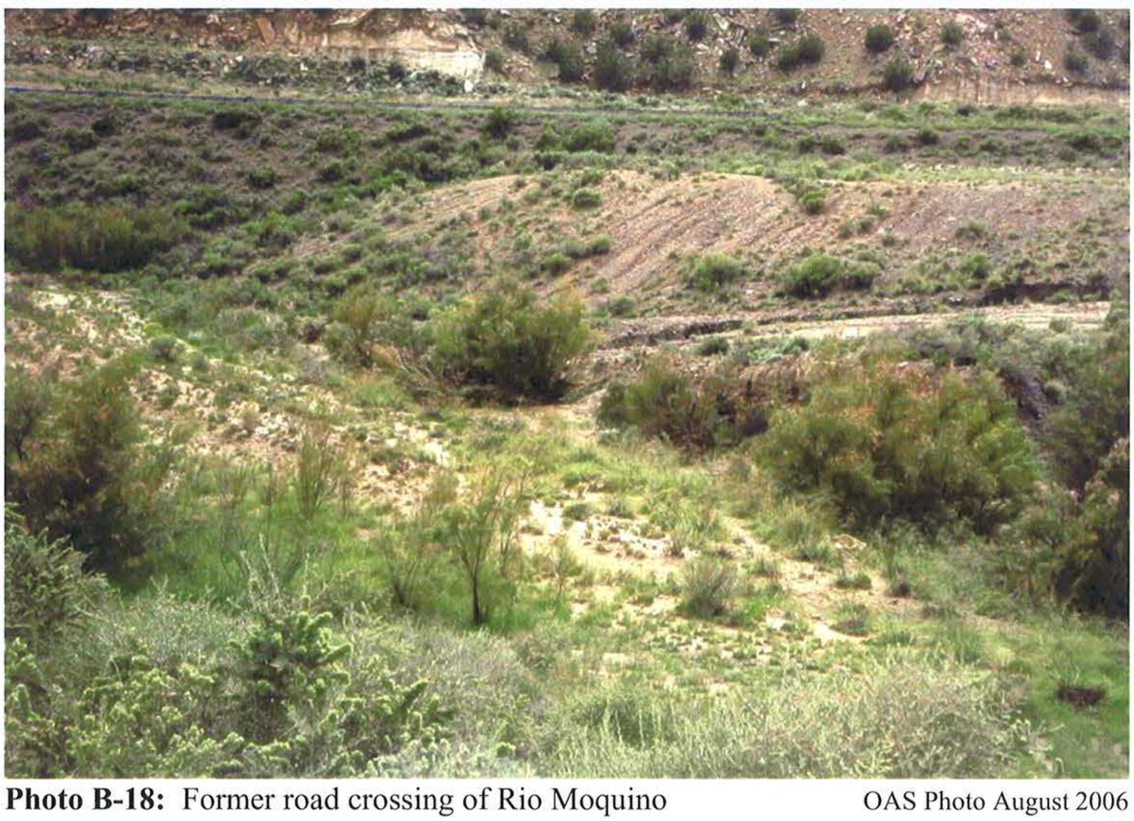

**Photo B-18:** Former road crossing of Rio Moquino OAS Photo August 2006

**Photo B-19:** End of Headcutting , Area of Exposed Sandstone OAS Photo August 2006

**Photo B-20:** In the background is Waste Pile "J" which was left in place, the area in front is the east side of "J" and contained the former protore piles "SP-6B and SP-17B C". OAS Photo August 2006

**Photo B-21:** Blocked Drainage North of FD-1 OAS Photo August 2006

**Photo B-22:** P-10 Well and Tank. OAS Photo August 2006

**Photo B-23:** New Shop Well and Tank. OAS Photo August 2007

# APPENDIX C

## JACKPILE-PAGUATE URANIUM MINE
## SITE MAPS (on CD-ROM)

**EXHIBIT 1 – 2003 AERIAL PHOTOGRAPH – WITH SITE FEATURES OF THE JACKPILE-PAGUATE URANIUM MINE**
**EXHIBIT 2 – 1995 TOPOGRAPHIC BASE MAP – WITH SITE FEATURES OF THE JACKPILE-PAGUATE URANIUM MINE**


Jackpile-Paguate
Uranium Mine
Record of Decision
Compliance Assessment
CD-ROM
September 2007
Appendix C
Exhibit 1 & Exhibit 2
Aerial Photo & Topo Map
Prepared by: OA Systems Corporation
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Amarillo, Texas 79109

# APPENDIX D

## ANALYSIS AND REVIEW OF:
## RE-VEGETATION,
## CEDAR CREEK VEGETATION SURVEY,
## GAMMA RAD-RADON GAS,
## SOILS AND UPTAKE,
## WATER QUALITY AND WATER QUALITY ADDENDUM
## (Monitoring Results, Water Quality and Water Quality Addendum also on CD-ROM)

# JACKPILE-PAGUATE URANIUM MINE POST-RECLAMATION RE-VEGETATION SUCCESS ANALYSIS

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## 1.0 INTRODUCTION

This report presents a review of post-reclamation vegetation monitoring data and an analysis of vegetation success for the reclaimed Jackpile-Paguate Uranium Mine.

The objectives of this report are to:

1. Determine if the post-reclamation vegetation monitoring has met the requirements of the Jackpile-Paguate Reclamation Project Record of Decision (ROD) ($DOI_2$, 1986) as defined in the Environmental Impact Statement ($DOI_1$, 1986)
2. Analyze the vegetation survey data collected to determine if the vegetation parameters met the requirements established in the ROD.
3. Determine if the revegetation on the reclaimed mine is stable and self-sustaining.
4. Make recommendations on how to overcome any ROD deficiencies.

The following provides an overview of the reclamation and revegetation on and around the mine site, previous studies on reclamation, and the basis for making decisions on the mine reclamation status.

## 2.0 BACKGROUND

The area of the mine and surrounding landscape is a region of broad mesas and plateaus separated by deep canyon, dry washes, and broad alluvial valleys on the southeastern edge Colorado Plateau province. This is a semi-arid region that supports grasslands dominated by blue grama/galleta on the mesas and uplands, and alkali sacaton in the valleys.

This project involved the reclamation of the three open pits, 32 waste dumps, 23 protore (sub-grade ore) stockpiles, four topsoil stockpiles, as well as roads and buildings on the remaining 2,656 acres of disturbed land.

As defined in the ROD, the objectives of the reclamation are:

1) To ensure human health and safety.
2) To reduce the release of radioactive elements and radionuclei to as low as reasonably achievable.
3) To ensure the integrity of all existing cultural, religious and archeological sites.
4) To return the vegetative cover to a productive condition compatible with the surrounding area.
5) Provide for additional land uses that are compatible with other reclamation objectives and that are desired by the Pueblo of Laguna.
6) Eliminate the need for post-reclamation maintenance.
7) Blend the visual characteristics of the mine with the surrounding terrain.
8) Employ the Pueblo of Laguna people in efforts that afford them opportunities to utilize the skills or train them as appropriate.

In addition, it was also important to determine if the EIS and the ROD requirements are still applicable to the mine site after 20 years because reclamation techniques have improved and the knowledge base has been enhanced. To perform this evaluation, the following reports and surveys were reviewed and analyzed:

1. Jacobs Engineering Group, Inc., *"Jackpile Project, Final Environmental Monitoring Plan"*, 1989.
2. United States Government, Soil Conservation Service-Memorandum, Noel Marsh, Area Range Conservationist, *"Trip report-review current plans, specifications and problems pertaining to revegetation of the Jackpile mine reclamation area"*, March 13, 1990.
3. United States Government, Soil Conservation Service-Memorandum, Allan Ardoin, Area Soil Scientist, *"Trip report-Review of Jack Pile Mine Reclamation by Area Soil Scientist and Area Range Conservationist"*, March 23, 1990.
4. Landmark Reclamation/Weston, *"Jackpile Reclamation Project, Pueblo of Laguna, New Mexico, Soils and Vegetation Evaluation for Final Reclamation"*, Final, April 1991
5. Munk, Lewis P. and Boden, Paul, Soils and Biogeochemistry, *"Interim Reclamation Success Analysis, North and South Paguate Open Pits, Jackpile-Paguate Uranium Mine"*, December 1996.
6. USDA, Natural Resources Conservation Service, National Range and Pasture Handbook-*Inventorying and Monitoring Grazing Land Resources*, Chapter 4, 1997.
7. USDA, Natural Resources Conservation Service, Paguate-Jackpile Mine 1998 Vegetative Inventory [Production Surveys], 1998
8. USDA, Natural Resources Conservation Service, Vegetation Inventory, Production Surveys, August 16, 2000.
9. USDA, Natural Resources Conservation Service, Vegetation Inventory, Production Surveys, September 7, 2006
10. Cedar Creek Associates, Inc. & S. Lynn Bamberg, LLC, *"2006 Vegetation Monitoring, Jackpile Paguate Reclamation Project"*, November 2006.

Reclamation and revegetation techniques were first tested by the Anaconda Mining Company (AMC) starting in 1976 on a mining waste pile of 50 acres, and continued on 11 additional waste piles in 1977, 1979, and 1980-1981 (Weston, 1991). The techniques AMC tested included the development topsoiling procedures based on soils analysis, seed mixtures, fertilization, and straw mulching. The results of the revegetation testing showed abundant vegetation on some waste piles and poor results on others.

There was no site activity from 1982 to 1989. Final reclamation of the entire mine site started in 1990, and was completed at the end of 1996. The 10-year ROD compliance monitoring requirement for vegetation started in January 1996, and was completed in November 2006.

The basic reclamation techniques used in the final reclamation from 1990-1996 were to fill in the pits with protore and mine wastes, slope and grade areas to be reclaimed, cover with up to 24 inches of topsoil, fertilize and seed the prepared surfaces. Site stability and erosion was controlled by sloping and armoring waste dumps and pit slopes.

## 3.0 REQUIREMENTS OF THE ROD AND EIS

Several of the requirements of the ROD and EIS address the revegetation and topsoiling procedures to be followed, the monitoring period, and success criteria for vegetation. Revegetation methods are given in Section 9 of the ROD, and state that:

- Topsoil (Tres Hermanos sandstone) will be placed in the pit bottoms, waste piles, and other areas of the mine,
- Surface preparation using fertilizer, discing, and contour furrowing,
- Seeding and seed mixtures consisting of native plant species compatible with post-mining grazing and local environmental, and
- Plant establishment will be considered successful when revegetated areas reach 90% of the density, frequency, foliar cover, basal cover, and production of undisturbed reference areas (but not sooner than 10 years following seeding).

The monitoring period for vegetation success was therefore established to be 10 years with the frequency and type of monitoring surveys not specified. Table 1-5 in the EIS specifies annual monitoring on pit bottoms, waste dumps, and reference areas for density, frequency, foliar cover, basal cover, and production using a Community Structure Analysis (CSA) method. The proposed monitoring program is presented in Table 3-1.

**Table 3-1**
**Proposed Vegetation Monitoring Program in the EIS ($DOI_1$, 1986)**

| Item | Proposed Vegetation Monitoring for Proposed Alternative | |
|---|---|---|
| **Vegetation success** | **Stations** | Waste dumps, pit bottoms, off-site reference areas |
| | **Parameters** | Density, frequency, foliar cover, basal cover, and production |
| | **Frequency** | Annually |
| | **Duration** | 10 years after seeding. |

Several interim documents deal with the sampling type and frequency, and success criteria for vegetation. The monitoring plan proposed by Jacobs Engineering (Jacobs 1989), describes a program of vegetation surveys that presents methodology and frequency of sampling that is virtually identical to the ROD and EIS requirements. The Soils and Vegetation Evaluation for Final Reclamation, Jackpile Reclamation Project (Landmark/Weston 1991) suggests a single set of vegetation standards was needed rather than using multiple reference areas, and presents a vegetation ranking system to determine monitoring and successful release for post-mining land uses. The specific criteria are an average of values from literature and surveys on and adjacent to, the Jackpile mine. The monitoring report for interim reclamation success (Munk and Boden, 1996) states that the use of reference areas as a reclamation standard is complicated by the lack of a model reference with ideal site characteristics. The report also states, "*...the reclamation success is obscured by these simple single parameter statistical comparisons* *because of differences in the vegetative composition among the reclaimed and reference areas.*"

## 4.0 VEGETATION PARAMETERS MONITORED AND METHODS

Most of the required vegetation parameters were monitored during the three periods referenced below.

1. In October 1990 (Weston 1991) both reclaimed mine areas and undisturbed reference areas were surveyed for foliar cover, basal cover, frequency, density and production. Vegetative data was collected using line intercept and the quadrat methods at twelve locations on and off the site.

2. In September/October 1996 (Munk and Boden 1996), the reclaimed mine sites were surveyed for vegetation in the North and South Paguate pits and two reference areas for all the required parameters. Plant production was for perennial grasses only, without shrubs or forbs. They monitored a total of 40 plots in three pits, and 30 plots in the two reference areas using a transect/quadrat system.

3. In November 2006 (Cedar Creek, 2006) the North and South Paguate Pits were surveyed for vegetation for foliar cover and plant production using a transect/production plot method. After an initial reconnaissance of the entire pit area, three representative "sites" were selected. At each of the three sites, five cover transects were sampled in a spoke-like manner radiating from the center of the site and five production samples were placed at the end of each transect. In addition, a qualitative rating of six specific parameters (wind erosion, water erosion, soil crust, plant vigor, seedlings, and seed reproduction) was conducted along each transect. The final evaluation at each site was a qualitative assessment of the rangeland health using indicators and rating categories developed by the Natural Resource Conservation Service (NRCS).

In order to determine trends in vegetation progress the NRCS (NRCS 1998, 2000, 2006) sampled the vegetation for plant production at various locations in the pit bottoms. The vegetation was sampled using a clipped quadrat and estimation method to determine pounds per acre of current production.

## 5.0 RESULTS

The results of the monitoring indicate that the revegetation across the reclaimed mine areas has been successful based on the criteria developed by Landmark/Weston after the monitoring of 1990. After the monitoring of 1990, Landmark/Weston determined that basal area data were inconsistent, and of little comparative value. The performance criteria in the ROD are not applicable to the Jackpile reclaimed lands, since no comparable reference areas area available. The other values of cover, density, and production varied greatly depending on the year and area surveyed. It was recommended that the specific vegetation ranking criteria be developed based on acceptable values rather than specific reference sites. Using these criteria, the report stated "*All of the reclaimed sites except one (vegetation survey site V-4) could be released for post-reclamation land uses without further monitoring.*" The 1991 report also suggested that monitoring frequency be determined by the ranking based on acceptable vegetation criteria presented in Table 3.6. The NRCS methodology document (NRCS 1997) described trends and rangeland ecological health attributes, but provided no health rating system.

The vegetation ranking criteria proposed in Tables 3.5, 3.6 and 5.6 from the Landmark/Weston 1991 report has been combined for this report and is presented in Table 5-1 below. As proposed in Table 5.6 of the Landmark/Weston 1991 report, and shown in the right hand column in Table 5-1 below, final release of the vegetation requirement could be made if, after 10 years, the composite vegetation ranking was good to excellent and the trend was stable.

**Table 5-1**
**Specific Vegetation Ranking Criteria for Reclaimed Land, Composite Ranking Value and Monitoring Requirements**
**(compiled from Tables 3.5, 3.6 and 5.6 – Landmark/Weston 1991)**

| Specific Vegetation Ranking | Ranking Value | Foliar Cover* (%) | Basal Cover* (%) | Production* (lbs/acre) | No. of Species Present* | Composite Ranking Value | Final Release |
|---|---|---|---|---|---|---|---|
| Excellent | 10 | ≥ 18.0 | ≥ 8.0 | ≥ 1000 | 4 | $X^b \geq 36$ | After 10 years |
| Very good | 8 | ≥ 14.0 | ≥ 7.0 | ≥ 750 | 4 | $28 \leq x < 36$ | After 10 years, and stable or inclining trend |
| Good | 6 | ≥ 12.0 | ≥ 6.0 | ≥ 650 | 3 | $20 \leq x < 28$ | After 10 years, and stable trend |
| Fair | 4 | ≥ 10.0 | ≥ 4.0 | ≥ 450 | 2 | $12 \leq x < 20$ | Not allowed |
| Poor | 2 | ≥ 5.0 | ≥ 3.0 | ≥ 250 | 1 | $4 \leq x < 12$ | Not allowed |
| Failure | 0 | < 5.0 | < 3.0 | < 250 | 1 | $x < 4$ | Not allowed |

*Based on desirable species of grass
[b]X is equal to the summation of specific ranking values assigned to the four criteria in Table 3.4.

Data from the detailed monitoring reports in 1990 (Landmark/Weston 1991), 1996 (Munk and Boden 1996), 2006 (Cedar Creek 2006) and NRCS (1998, 2000, 2006) show a consistent inclining trend and pattern of good to excellent plant communities and vegetation based on cover, diversity, density, and plant production.

Data from the Landmark/Weston 1991, Munk and Boden 1996, Cedar Creek 2006 and NRCS 1998, 2000, 2006 reports is summarized below in Table 5-2.

**Table 5-2**
**Results of the Vegetation Monitoring, Pit Bottoms**

| Year | [1]Ref. | Foliar cover % | | Basal cover % | | [3]Diversity #/plot | | Density $\#/m^2$ | | Production lbs/ac | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mine | Ref | Mine | Ref | Mine | Ref | Mine | Ref | Mine | Ref |
| 1990 | 1 | 48.4 | 25.3 | 11.9 | 9.9 | 9.2 | 14.8 | 30.3 | 59.5 | [2]1043 | [2]1343 |
| 1996 | 2 | 42.6 | 50.4 | 6.4 | 7.4 | 10.0 | 11.0 | 20.0 | 38 | [2]603 | [2]328 |
| 1998 | 3 | - | - | - | - | 17.0 | 12.3 | - | - | [4]884 | [4]573 |
| 2000 | 3 | - | - | - | - | 11.0 | - | - | - | [4]523 | - |
| 2006 | 3 | - | - | - | | 10.0 | - | - | - | [4]938 | - |
| 2006 | 4 | 49.4 | - | - | - | 13.0 | | | - | [4]825 | - |

[1]References: 1-Weston 1991: 2- Munk and Boden 1996: 3- NRCS 1998, 2000, 2006: 4- Cedar Creek 2006
[2]perennial grasses only, wet weight
[3]Numbers of species recorded per plot, also called species richness
[4]Total vegetative production, dry weight

Information provided in the 1990, 1996 and 2006 monitoring reports consistently indicated that vegetation on the reclaimed mine areas could be considered successful in meeting the primary goals of landscape stability, productivity, and well established plant communities. According to the cover and productivity, two of the important parameters for determining vegetation trends, the reclaimed mine areas showed good to excellent vegetation from 1990 until late 2006. Frequency (percentage that a plant species occurs in sample plots) was not a good measure of plant success; however, diversity of the reclaimed plots surveyed was as good, or better, than the natural vegetation indicating good vegetation structure. Plant production varied greatly between years measured due to differences in timing and amounts of rainfall. The years from 1999 to 2005 were drought years in this region with poor plant growth.

The 1996 monitoring activities were conducted, and the monitoring report prepared (Munk and Boden 1996), at the end of the active reclamation program during a season of good rainfall. The results of this interim monitoring indicate that, *"In general, reclamation in the pit bottoms can be considered successful in meeting the goals of landscape stability, productivity, and containment of the protore."* (Munk and Boden 1996). The reclaimed areas did not meet the strict numerical standards of the ROD requirements, but had vigorous and productive plant communities with desirable perennial grasses and shrubs. There were less desirable annual grasses in the reference areas due to past grazing and land use practices.

Monitoring activities in the 2006 monitoring report (Cedar Creek 2006), in addition to assessing cover and productivity, followed suggested protocol based on NRCS methods for evaluating and rating ecological sites for health and stability in Chapter 4 of the National Range and Pasture Handbook for inventorying and monitoring land resources. The sampling and monitoring results compared these naturalized plant communities (on the reclaimed mine site) to the desired plant community based on the reclamation and revegetation techniques (grading, topographic and water control, and seed mix) used on the Jackpile mine. The trends and ecological health of the plant communities, and other physical attributes, showed excellent balance and sustainability of the reclaimed areas for physical structure (topography, soils), hydrology (streams, runoff, watersheds, pools, springs and seeps), and ecology (vegetation, animals, and habitats).

In summary, plant productivity surveys conducted by NRCS (NRCS 1998, 2000, and 2006) confirmed the stability and trend in the vegetation on reclaimed areas. Productivity of the vegetation was consistent and was influenced by the local weather patterns. For example, productivity was lower in the drought year of 2000, but had recovered and was very productive in 2006. The summer and fall of 2006 had abundant and well-spaced rains and the vegetation responded with good productivity. Perennial grasses were tall and produced abundant seed. Vegetation and surface stability was observed in early fall after a record amount of rainfall during the "monsoon" season in mid to late summer. There was excellent growth and productivity of the vegetation due to the abundant soil moisture. There was a diversity of desirable perennial grasses, shrubs, and forbs in the pits, side slopes, and level areas that formed stable vegetation communities. Some minor surface gullies formed, which were repaired, and had started revegetating naturally from the abundant seed bank in the soils. Some low depressions in the filled mine pits still had standing water from runoff,

## 6.0 DISCUSSION OF RESULTS

The results of the vegetation monitoring show good to excellent plant communities with total foliar cover values of 43-50%; according to Landmark/Weston (1991) regional values are 10.3% to 26.5%, so the cover values far exceed the 90% specified in the ROD; and plant production of 523-1043 lbs/ac on the reclaimed areas. The trends in vegetation are stable for plant diversity and health. The reclaimed mine areas can be considered successfully revegetated based on the available monitoring data. The reclaimed mine has a stable and self-sustaining diverse ecosystems with very good to excellent vegetative cover and productivity of desirable plant species, and good habitat for local wildlife. There are no comparable reference sites for determining the success standards of these ecosystems as required by the ROD. However, not meeting the ROD requirements is acceptable because there are no suitable or comparable reference sites available. It should be noted, however, that the ROD has been more than adequately met. The recommendations of the monitoring reports and this summary are that the mine has successful vegetation based on plant cover, production and other criteria of stability and sustainability.

The reclaimed mine can be released from the 10-year monitoring period based on revegetation success. Post-reclamation land uses can be instituted based on future management decisions. These land uses were listed in the ROD as grazing, light manufacturing, office space, mining, and major equipment storage. There was concern expressed by allowing livestock grazing in the pit bottoms because of potential uptake of metals and radionuclides. This is discussed in the plant uptake evaluation (OA Systems Corporation, *Jackpile-Paguate Uranium Mine Record of Decision Compliance Assessment*, Appendix A, 2007).

## 6.1 Data Condition

The available data from the vegetation surveys were evaluated for applicability to the revegetation monitoring. The sampling periods were adjusted based on vegetative growth and drought years. An evaluation of the concurrent and post reclamation vegetation monitoring data is presented in Table 6-1. The lack of vegetation monitoring during the period of 2000 until fall of 2006 was the most significant problem.

**Table 6-1**
**Evaluation of Concurrent and Post Reclamation Vegetation Monitoring Data**

| Positives | Negatives |
|---|---|
| • Reports were clear and concise.<br>• Survey methods were adequately explained.<br>• Reports were consistent for vegetation success<br>• Protocol for determining ecological health and stability were positive.<br>• Overall, vegetation was good to excellent over the entire mine site.<br>• Procedures for reestablishing vegetation were followed and produced good results. | • Not all vegetation parameters were measured during each period.<br>• Methods were not standardized for yearly comparisons.<br>• Vegetative trends were inferred from incomplete surveys.<br>• Several years from 1996 to 2006 had no data or surveys.<br>• Not all parameters suggested by the Environmental Monitoring program were analyzed for each year |

## 6.2 Vegetation Conditions

Overall, revegetation in the pit bottoms and slopes that were sampled was excellent and especially robust in the above-average precipitation year 2006. The blue grama seed heads were nearly hip high, and other grasses were tall and produced an excellent seed crop. Plant diversity within the revegetation was better than expected given the seed mixtures used or 7-9 species, however 72 plant species (Munk and Boden, 1996) were noted in the reclaimed areas mostly from natural seed dispersal processes. With the exception of low forb species and lack of biological crusts, all the rangeland health indicators were rated as having little or no departure from the ecological site descriptions. With respect to the key qualitative parameters, all were rated in the highest or next-to highest category except for soil crusts (Cedar Creek 2006). Soil crusts are more common with longer soil development.

The reclaimed vegetation is a grassland/shrub community dominated by native grass species, and a sub-component of shrubs. Grasses are dominant in most areas followed by forbs and shrubs. The pit bottoms had two types of vegetation: 1) drier sites in these areas had dominant taxa of blue grama (*Bouteloua gracilis*), side-oats grama (*Bouteloua curtipendula*), four-wing saltbush (*Atriplex canescens*), and alkali sacaton (*Sporobolus airoides*) with 27.1%, 12.7%, 9.1%, and 3.5% cover, respectively; and 2) in moist areas the dominant taxa were alkali sacaton, four-wing saltbush, galleta (*Hilaria jamesii*), and blue grama with 22.5%, 3.8%, 2.2%, and 1.5% cover, respectively. Slopes and tops of reclaimed areas have different dominant species in addition to blue grama and galleta with side-oats grama, Indian ricegrass, and yellow sweet clover dominant in some areas. Vegetation on reclaimed sites is diverse, vigorous, and well established.

## 7.0 CONCLUSIONS AND RECOMMENDATIONS

Based on this vegetation review, the following conclusions can be drawn:

1. The Jackpile Reclamation Project post reclamation vegetation monitoring program deviated from the requirement of the Record of Decision. This was due to modifications in determining vegetative success that was the result of a prolonged drought, as documented in local reports. The monitoring met the intent of the ROD in determining vegetation success, in that the mine was very successfully revegetated based on important vegetation parameters of cover and productivity. The revegetation results did not meet the strict numerical standards of the ROD, but there were vigorous and productive plant communities with desirable perennial grasses and shrubs throughout.
2. As presented in Table 5-1, and discussed in Section 6.2, the condition of post-reclamation vegetation is very good to excellent, and the reclaimed mine has stable and self-sustaining diverse ecosystems, and good habitat for local wildlife.
3. Trends in vegetation are stable for plant diversity and health.
4. The reclaimed mine can be released from the 10-year monitoring period based on revegetation success.
5. Some minor surface gullies formed from record rainfall in 2006 that were repaired and revegetated naturally from the abundant seed bank in the soils.
6. There are no hazards to human health and safety from the current vegetation conditions on the reclaimed mine. The potential for hazards to livestock is discussed in the plant uptake evaluation (OA Systems Corporation, *Jackpile-Paguate Uranium Mine Record of Decision Compliance Assessment*, Appendix A, 2007).

Based on these conclusions, the following recommendations can be made:

1. Vegetation on the reclaimed mine is currently stable and successful.
2. The 10-year monitoring period appears to be sufficient to assess the revegetation and future formal monitoring does not appear to be warranted.
3. Management practices should consider the entire mine site as a resource unit and develop a future management plan along with other units on the Pueblo of Laguna. Future access, roads, and fences should be designed for the management unit.
4. Surface water management plans may need to review the surface runoff options for controlling rills and erosion as it relates to vegetation. Water is concentrated off the faces of the reclaimed waste dumps into long contours that need to be reduced in length. Runoff and water drainage on the reclaimed surfaces should be

allowed to develop channels that will not need to be managed or repaired in the future.

5. Ponds and wetlands are developing in some of the depressions of the mine pits, and are a desirable and productive type ecosystem that should be retained.

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# 2006 Vegetation Monitoring
# Jackpile Paguate Reclamation Project
# Cedar Creek Associates,
# November 2006

## 1.0 Introduction

The Jackpile Paguate reclaimed mine was monitored for vegetation success during November 2006 for the 10-year monitoring requirement according to the Record of Decision (ROD 1986). This vegetation monitoring event was conducted by Cedar Creek Associates, Inc. using standard and up-to-date methodology.

The two pits in the South Pit area (SP-34 and SP-35) and the one pit in the North Pit area (NP-20) were sampled. The Jackpile Pit was sampled in September 2006 for production by NRCS. Three sites within each pit were selected for sampling. The SP-35 pit had developed three fairly distinct communities and one sampling site was placed in each of these. The SP-34 pit was fairly homogeneous (besides the ponds / wet areas) and the sites were equidistantly placed. The NP-20 pit exhibited two communities / soil types, and two sites were located in the larger galleta community while one was placed in the smaller rockier soil area. At each site, five representative cover transects and production quadrats were placed in the area. The six specific parameter were rated at each cover transect and then the 18 NRCS rangeland heath indicators were estimated for the entire site area.

All the specific parameter ratings, NRCS ratings, cover data summary, production data summary, and notes for each site were organized onto Excel worksheets (Jackpile Qualitative, which are available on a CD upon request.). Other summary cover tables and charts, as well as raw data tables are on two files (Jackpile Cover and Jackpile Prod, available on CD). Landscape and ground photographs of each sample site, as well as overview shots of the pits are provided individually and in a four-per-page presentation format (also available on CD upon request). A map of each of the pits with sample site locations and miscellaneous notes are provided in a JPEG format. The following presents the methodology for the cover and production portions of this evaluation as well as a brief synopsis of each pit area.

Overall, the revegetation effort in the pit bottoms that were sampled was excellent and especially robust in this above-average precipitation year. It was difficult to find any major faults with the reclamation effort, except that plant diversity within the revegetation was lower than expected given the seed mixes used. With the exception of low forb diversity and lack of biological crusts, all the rangeland health indicators were rated as excellent and having little or no departure from the ecological site descriptions. With respect to the key qualitative parameters, all were rated in the highest or next-to highest category except for soil crusts.

## 2.0 Methodology for Quantitative and Qualitative Vegetation Sampling

### 2.1 Sample Site Selection and Evaluations

The sample layout protocol for revegetation evaluations in 2006 largely followed procedures developed by Cedar Creek Associates, Inc. to provide representative and cost-effective data for evaluation of revegetation. After an initial reconnaissance of the entire pit area, three representative "sites" were selected (see Maps 1-3). Placement of these sites took into account factors such as dominant vegetation, topography, distance from other sites, and different seed mixes and/or years. At each site, five cover transects were sampled in a spoke-like manner radiating from the center of the site and five production samples were placed at the end of each transect (Note: Figure 1 shows the production quadrat at the beginning of each transect). In addition, a qualitative rating of six specific parameters (wind erosion, water erosion, soil crust, plant vigor, seedlings, and seed reproduction) was conducted along each transect. The final evaluation at each site involved a qualitative assessment of the rangeland health using indicators and rating categories developed by the National Resources Conservation Service (NRCS).

### 2.2 Determination of Ground Cover

Ground cover at each sample point was determined utilizing the point-intercept methodology as illustrated on Figure 1. As indicated on this figure, Cedar Creek utilizes new state-of-the-art instrumentation it has pioneered to facilitate much more rapid and accurate collection of data. A transect of 10 meters length was extended in the direction of the next sampling location from the flagged center of each systematically located sample point. At each one-meter interval along the transect, a "laser point bar" was situated parallel to, and approximately 4.5 to 5.0 feet vertically above the ground surface. A set of 10 readings was recorded as to hits on vegetation (by species), litter, rock (>2mm), or bare soil. Hits were determined at each meter interval by activating a battery of 10 low-energy specialized lasers** situated along the bar at 10 centimeter intervals and

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** Lasers utilized for this instrument are state-of-the-art and are a specialized design to emit a unique electro-magnetic wavelength visible under full sunlight, a condition previously not possible with portable low-energy lasers.

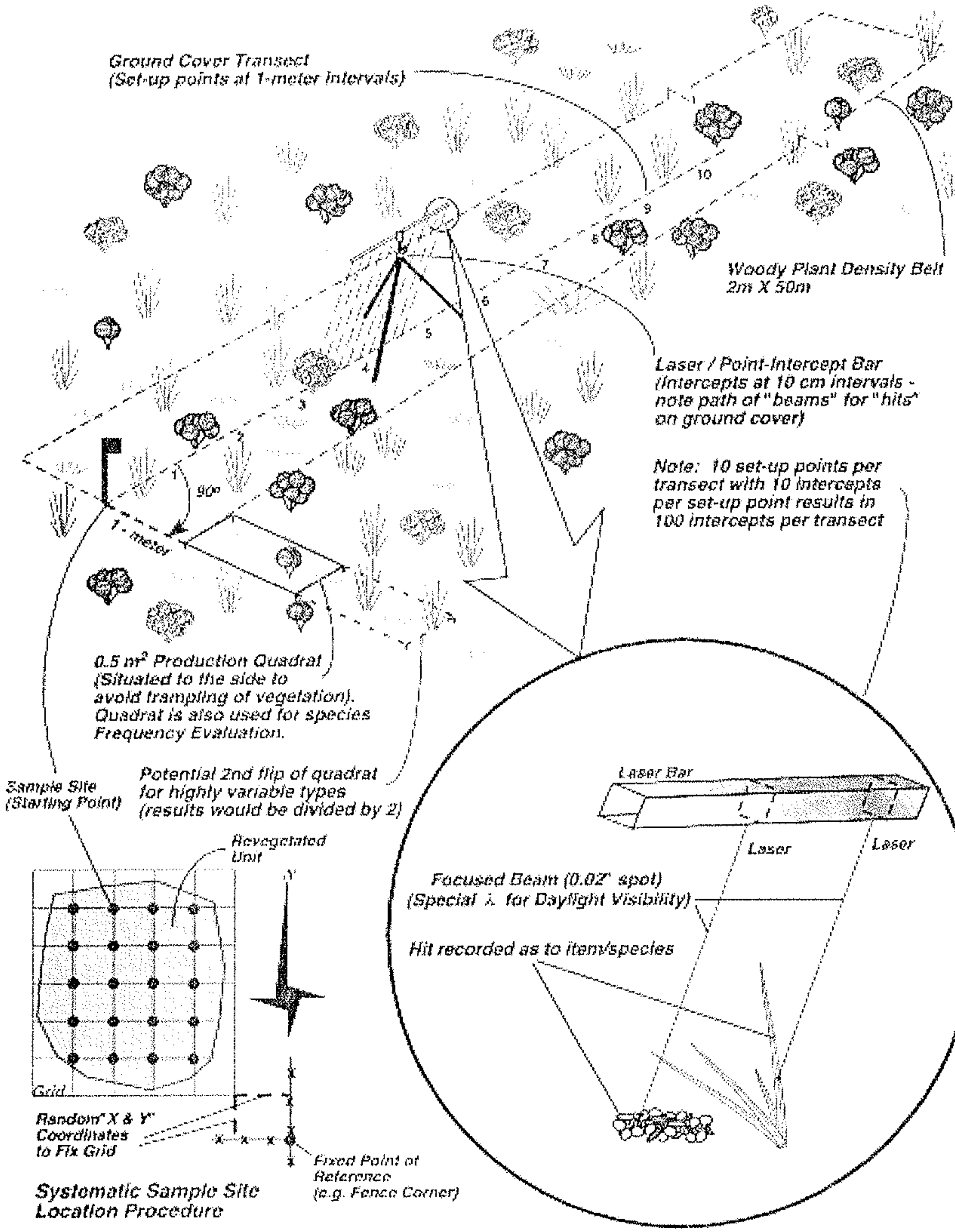


**Figure 1**

*Sampling Procedure at a Systematic Sample Site Location* recording the variable intercepted by each of the narrowly focused (0.02") beams (see Figure 1). In this manner, a total of 100 intercepts per transect were recorded resulting in 1 percent cover per intercept. This methodology and instrumentation facilitates the collection of the most unbiased, repeatable, and precise ground cover data possible.

## 2.3 Determination of Current Annual Production

At the end of each cover transect, current annual production was collected from a $^1/_2$ $m^2$ quadrat frame placed one meter and $90^o$ to the right (clockwise) of the ground cover transect to facilitate avoidance of vegetation trampled by investigators during sample site location (see Figure 1). From within each quadrat, all above ground current annual vegetation within the vertical boundaries of the frame were clipped and bagged separately by life form as follows:

| | |
|---|---|
| Perennial Grass | Perennial Forb |
| Annual Grass | Annual Forb |
| Shrub | Sub-shrub |

In addition, the percentage of warm-season grasses that made up the perennial grass total was estimated to the nearest 5%. All production samples were weighed in the field (wet weights) and then returned to the lab for drying and weighing. Samples were air-dried until a stable weight was achieved (7 days). Samples were then re-weighed to the nearest 0.1 gram.

## 2.4 Sample Adequacy Determination

Fifteen cover samples within each pit area were collected (five from each site). From these preliminary efforts, sample means and standard deviations for total non-overlapping vegetation ground cover were calculated. For non-monitoring applications, the typical procedure is that sampling continues until an adequate sample, $\mathbf{n_{min}}$, has been collected in accordance with the Cochran formula (below) for determining sample adequacy, whereby the population is estimated to within 10% of the true mean ($\mu$) with 90% confidence.

When the inequality ($\mathbf{n_{min} \leq n}$) is true, sampling is deemed adequate; and $\mathbf{n_{min}}$ is determined as follows:

$$\boxed{\mathbf{n_{min}} = (t^2\, s^2) \,/\, (0.1\, \overline{X}\,)^2}$$

where: $n$ = the number of actual samples collected (initial size = 15 or 20)

$t$ = the value from the two-tailed $t$ distribution for 90% confidence with n-1 degrees of freedom;

$s^2$ = the variance of the estimate as calculated from the initial samples;

$\overline{x}$ = the mean of the estimate as calculated from the initial samples.

If the initial samples do not provide a suitable estimate of the mean (i.e., the inequality is false), additional samples would be collected until the inequality ($\mathbf{n_{min} \leq n}$) becomes true. However, because sampling is for managerial (monitoring) information, adequacy is not necessary and is calculated for informational purposes only.

## 2.5 NRCS Rangeland Health

This suggested protocol is based on NRCS methods for evaluating and rating ecological sites for health and stability as given in Chapter 4 of the National Range and Pasture Handbook for inventorying and monitoring land resources. Sampling and monitoring results will be used to compare these naturalized plant communities (on the reclaimed mine site) to the desired plant community based on the reclamation and revegetation techniques (grading, topographic and water control, and seed mix) used on the Jackpile mine. Trends and ecological health of the plant communities and other physical attributes will be used to determine balance and sustainability of the reclaimed areas. The NRCS also mentions history (when reclaimed) and yearly or other monitoring results to determine trends

The characterization of the reclaimed site has three basic parameters:

Physical structure - topography, soils

Hydrology - streams, runoff, watersheds, pools, springs and seeps

Ecology – vegetation, animals, and habitats.

To determine ecological health and stability, NRCS uses the following attributes

1. Rills
2. Gullies
3. Water flow patterns, channels, streams
4. Wind erosion
5. Bare soil
6. Soil pedestals

7. Soil surface features
8. Cryptobiotic crusts
9. Water infiltration and runoff
10. Plant species composition
11. Functional plant groups – life forms, seasonality, layering
12. Annual productivity and total biomass
13. Plant vigor
14. Recruitment, reproduction, seed production, seedlings
15. Plant mortality
16. Plant stress
17. Litter and plant residues
18. Invasive species (exotics, aliens, "weeds", noxious)

In addition to ground cover and annual production, the following parameters can be measured or estimated using a plotless technique:

plant species composition to determine functional groups and layering (list all plant species observed in the area.

-

wind and water erosion (on a scale: 1=severe, to 5=none)

soil crusts (scale: 1=none, 5=good microbiotic crust)

plant vigor/stress (scale: 1=stressed, some mortality, to 5=vigorous)

seed or propagules production, seedlings (scale 1=none, to 5=excellent seeds/reproduction)

## 3.0 Results of the Monitoring

Overall, the revegetation effort in the pit bottoms that were sampled was excellent and especially robust in this above-average precipitation year (the blue grama seedheads were nearly hip high). It was difficult to find any major faults with the reclamation effort besides the obvious high water table/ponding issues and lack of any biological crusts. During these late fall surveys the plant diversity within the revegetation was low and forbs were not observed. Grass diversity decreased as the water table neared the surface (the wetter and more alkaline locations). Nearly all soil surfaces in the pit exhibited varying degrees of "plate" formation which is typically associated with drying mudflats. It appears that nearly all of these pit bottoms experienced standing water for some period of time this past monsoon season. Most vegetation seems to have withstood this inundation and benefited, but some saltbush and snakeweed may have died. It was difficult to tell whether many of these plants were decadent, senescent or dead. This was especially hard at sample site #2 in the SP-35 pit.

South Pit – SP-34

The SP-34 Pit was sampled with 15 transects in 2006 and is exhibiting excellent revegetation. Perusal of Table 3.1 indicates that the total cover in this area was 58.1% with an average perennial cover of 57.5%. Dominant taxa in this area were blue grama (*Bouteloua gracilis*), side-oats grama (*Bouteloua curtipendula*), four-wing saltbush (*Atriplex canescens*), and alkali sacaton (*Sporobolus airoides*) with 27.1%, 12.7%, 9.1%, and 3.5% cover, respectively. Air-dry production averaged 923 pounds per acre with warm-season grasses averaging 723 pounds per acre and shrubs averaging 194 pounds per acre. The three sample sites were very similar with respect to cover and production with only slight variations in plant composition, bare ground and litter values. With the exception of low forb diversity and lack of biological crusts, all the rangeland health indicators were rated as having little or no departure from the ecological site descriptions. With respect to the key qualitative parameters, all were rated in the highest or next-to highest category except for soil crusts.

Table 3-1. Results of the Vegetation Monitoring at the Jackpile Mine. November 2006

| Plant Canopy Cover - % | | | |
|---|---|---|---|
| | South Pit – SP-34 | South Pit – SP35 | North Pit – OP20 |
| Total Plant Cover | 58.13 | 34.33 | 55.67 |
| Rock | 1.27 | 0.07 | 3.80 |
| Litter | 12.93 | 17.13 | 13.47 |

| | | | |
|---|---|---|---|
| Bare ground | 27.67 | 49.47 | 27.07 |
| Plant Production – lbs/acre (air dry) | | | |
| | South Pit – SP-34 | South Pit – SP35 | North Pit – OP20 |
| Perennial Grass | 722.78 | 466.07 | 783.81 |
| Annual Forbs | 12.14 | 7.61 | 28.84 |
| Subshrubs | 0.00 | 0.00 | 65.05 |
| Shrubs | 193.74 | 77.68 | 122.95 |
| TOTALS | 923 | 551 | 1002 |

South Pit – SP-35

The SP-35 Pit was sampled with 15 transects in 2006 and is exhibiting very good revegetation. Perusal of Table 11 indicates that the total cover in this area was 34.3% with an average perennial cover of 33.3%. Dominant taxa in this area were alkali sacaton, four-wing saltbush, galleta (*Hilaria jamesii*), and blue grama with 22.5%, 3.8%, 2.2%, and 1.5% cover, respectively. Air-dry production averaged 551 pounds per acre with warm-season grasses averaging 466 pounds per acre and shrubs averaging 77 pounds per acre. Three vegetation communities were apparent within the pit bottom with transitional ecotypes between each one (see Map 2). Along the eastern edge of the pit, deposition from the reclaimed slopes has produced a slightly sloped narrow strip of land where many of the more xeric seeded species are prevalent. This is the only site in this evaluation where any soil movement was observed. The second site within this pit was located in the central portion where four-wing saltbush and alkali sacaton dominate. This area is wetter and lacking in any grama species. As noted earlier, four-wing saltbush and snakeweed are mainly decadent and/or dead here, perhaps from too much standing water or for too long. The third community and site is located in a seasonally wet meadow that is dominated almost entirely by alkali sacaton. Cover and production values are lowest at this site. Rangeland health and key qualitative parameters are overwhelmingly positive at these three sites with a few exceptions (see Tables 4-6 for details).

North Pit – NP-20

The NP-20 Pit was sampled with 15 transects in 2006 and is exhibiting excellent revegetation. Perusal of Table 12 indicates that the total cover in this area was 55.7% with an average perennial cover of 51.5%. Dominant taxa in this area were galleta, snakeweed (*Gutierrezia sarothrae*), side-oats grama, yellow sweetclover (*Melilotus officinalis*), blue grama, and four-wing saltbush with 30.9%, 5.7%, 4.7%, 4.0%, 3.9%, and 3.3% cover, respectively. Air-dry production averaged 1,002 pounds per acre with warm-season grasses averaging 783 pounds per acre, sub-shrubs 65 pounds, and shrubs averaging 123 pounds per acre. The first two sample sites were very similar with respect to cover and production with only slight variations in plant composition, bare ground and litter values. Sample site #3 was located in the eastern third of the pit and apparently received a different growth medium than the rest of the pit. It appears that native topsoil was used due to the quantity and diversity of native taxa observed. In addition, the soil was rockier and little to no "shrink-swell" plates were noted (possibly due to elevated organic matter typical of topsoils). With the exception of low plant diversity, lack of seedlings, and no biological crusts, all the rangeland health indicators were rated as having little or no departure from the ecological site descriptions. With respect to the key qualitative parameters, all were rated in the highest or next-to highest category except for soil crusts.

## 4-0 Summary

Plant communities surveyed in the pit bottoms were vigorous and well established, and the rangeland health indicators were rated as having little or no departure from the ecological site descriptions. Plant cover and productivity in this year of abundant rain were high at 34 to 58% cover, and 551 to 1002 lbs per acre.

# POST-RECLAMATION
# GAMMA RADIATION AND RADON GAS ANALYSIS
# JACKPILE-PAGUATE URANIUM MINE

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## 1.0 INTRODUCTION

This report presents an evaluation of gamma radiation and radon gas surveys conducted for the reclaimed Jackpile-Paguate Uranium Mine.

The objectives of this report are to:

1. Determine if the post-reclamation monitoring for gamma radiation and radon gas monitoring met the requirements in the Jackpile-Paguate Reclamation Project Record of Decision (ROD) (DOI, 1986) as defined in Table I-5 of the Environmental Impact Statement (EIS) (DOI, 1986)
2. Review the survey reports and concentrations measured for compliance with the requirements of the ROD.
3. Make recommendations for future monitoring programs and management practices to ensure that the current reclamation status poses no hazards to the environment or human health.

The following presents an overview of the survey procedures, the results of monitoring of gamma radiation and radon gas, and the basis for making decisions on the mine reclamation and future land use status.

## 2.0 BACKGROUND

The EIS presented several reclamation activities and proposed treatments that were designed to reduce the potential for release and exposure to gamma radiation and radon gas. The activities and treatments were carried out during active reclamation and included:

1. Moving stockpiled protore (Jackpile Sandstone) into the pits and covering with overburden (Mancos Shale) and topsoil (Tres Hermanos Sandstone) before revegetation.
2. Covering exposed surfaces of Jackpile Sandstone on waste dumps with shale overburden and topsoil.
3. Clearing and moving contaminated materials from facilities, roads, rail spur, and disturbed sites; and topsoiling all disturbed sites (old roads, etc.) before reclamation.
4. Stabilizing waste dumps at 3:1 slopes, moving some dumps from drainages, and reducing pit highwalls.
5. Pits were to remain as closed basins and fenced to prevent access of domestic cattle and human entry.

This evaluation used the following reports and monitoring results:

1. Jacobs Engineering Group, *Jackpile Project Environmental Monitoring Plan*, Final, 1989.
2. U.S. Department of the Interior (DOI), *Final Jackpile-Paguate – Uranium Mine Reclamation Project Environmental Impact Statement, Vol. 1*, 1986.



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3. U.S. Department of the Interior (DOI), Bureau of Land Management, Memorandum to Bureau of Indian Affairs (BIA), *Subject: Radiological Monitoring, Jackpile Reclamation Project*, May 20, 1994.
4. Pueblo of Laguna, Reclamation Project Manager, *"Jackpile Reclamation Project, Pueblo of Laguna, New Mexico"*, Annual Report, 1996
5. Gamma and radon measurements in data sheets (Excel or PDF) for field surveys 1990 to 1996

Monitoring for gamma radiation and radon gas started with active reclamation activities in 1990 and continued until 1997 at the completion of reclamation.

## 3.0 REQUIREMENTS OF THE ROD AND EIS

Requirements of the ROD and EIS for monitoring gamma radiation and radon gas were specified in Table 1-5 in the EIS. The proposed monitoring program is presented as Table 3-1 below.

**Table 3-1**
**Proposed Gamma Radiation and Radon Gas Monitoring Program in the EIS ($DOI_1$, 1986)**

| Item | | |
|---|---|---|
| **Gamma Radiation** | **Stations** | Each waste dump and selected reclaimed areas |
| | **Frequency** | As needed |
| | **Parameters** | Ground survey plus final aerial survey |
| | **Duration** | Before seeding and once after reclamation is complete. |
| **Radon Gas** | **Stations** | 5 |
| | **Frequency** | Monthly |
| | **Parameters** | Rn-222 (pCi/L) |
| | **Duration** | A minimum of 3 years following reclamation. |

The specified limit for gamma radiation levels following reclamation was twice the background level of 14 micro Roentgens per hour (14μR/hr). The specified limit for radon gas levels after reclamation was 3 picocuries per liter (pCi/L) above background of 0.5 for a total of 3.5 pCi/L.

One document addressed the proposed monitoring program after final reclamation was complete. That document, the gamma radiation monitoring plan proposed by Jacobs Engineering (Jacobs 1989), suggested modifications of the requirements of the EIS as follows:

1. Aerial survey should be replaced by an extensive ground survey at 3 feet above ground because it is more accurate and less expensive.
2. All waste dumps with exposed Jackpile Sandstone (protore) or construction areas should be surveyed in a grid pattern prior to placement of shale and topsoil cover.
3. After initial excavation of construction areas or placement of topsoil, the area should be surveyed to determine areas that were twice the background level.

Radon gas surveys were to be modified as follows:

1. Radon was to be continuously monitored during construction at 15 locations on, and around the mine.
2. Radon was to be continuously monitored at 10 locations on and adjacent to the mine for four successive quarters after construction was complete.
3. Monitoring of radon flux was eliminated due to technical infeasibility, and because there was no standard for radon flux.

## 4.0 PARAMETERS MONITORED AND SAMPLING METHODS

Gamma radiation was measured using a TMA/Eberline gamma meter held three feet above the ground. The gamma surveys started during construction in 1990, and were concluded in 1993. There are no records of gamma radiation surveys after 1993. The following are the areas surveyed during the period of 1991 to 1993. They were selected based on recommendations from the EIS and monitoring reports.

1. Shops, construction buildings, and offices; housing area; Paguate townsite
2. Waste dumps and protore stockpile areas
3. Crusher areas; haul and access roads
4. Loading dock and rail spur from Quirk Station north to the project boundary (in 1990)
5. Three pits (North Paguate, South Paguate, and Jackpile) during backfilling and covering with shale and topsoil

Gamma radiation was measured using grids (100x100 feet or 200x100 feet) and recorded on field sheets, log and summary analytical sheets, and hand-drawn field maps. Measurements are recorded in micro Roentgens per hour (μR/hr).

Radon-222 gas was measured using Track Etch® cups (Barringer Alpha Track Detectors) at 15 predetermined locations on, and around, the mine as suggested by the monitoring report (Jacobs 1989). The cups were set up on posts three feet above ground at each location, and collected quarterly from April 1990 to May 1997. The monitoring station locations and time were recorded on Radon Test Detector log sheets or field forms, and the results listed on Radon Measurement Data sheets and Monitoring Reports for each quarterly testing period. The complete radon-222 survey results were tabulated and reported in the 1996 Annual Report for the Jackpile Reclamation Project. Measurements are reported in picocuries per liter (pCi/L).

## 5.0 RESULTS

Gamma Radiation: The results of the gamma surveys showed that open uncovered pits, protore (Jackpile Sandstone) stockpiles, and areas contaminated with ore (i.e., crusher areas, haul roads, etc.) averaged 62 to 173 μR/hr before reclamation activities. Waste dumps measurements varied depending on the surface materials from 19 to 48 μR/hr.

Shops and buildings on site initially measured 0.9 to 52 μR/hr in 1991/1992, but were cleaned and reduced to 0.9 to 14 μR/hr in 1993.

During construction and reclamation activities, protore and contaminated areas were removed and placed in pits, which were then covered with shale and topsoil. Measurements of gamma radiation levels on the shale cover in pits and on waste dumps were reduced to 14 to 28 μR/hr, and after topsoil placement the readings were reduced further to less than 10 μR/hr. Covering the protore and pits with shale and topsoil reduced gamma radiation to acceptable levels. There were no gamma surveys after 1993 when the pits were covered and reclaimed.

Radon Gas: The results of the radon gas surveys were summarized in a table in the 1996 Annual Report, a portion of which is abstracted and presented in Table 5-1 below. The averages of radon gas were all less than 2 pCi/L, and the average for all sites was 1.0 pCi/L. There was no measurement of radon gas above 2.9 pCi/L, which was measured in the Old Shop in 1990. It was subsequently cleaned to reduce radiation. Radon gas was monitored for four quarters after reclamation was completed, in May 1997. None of the radon gas measurements exceeded the limit of 3.5 pCi/L.

**Table 5-1**
**Averages of Radon Gas Measurements in pCi/L at 15 Site Locations**
**Jackpile Reclamation Project, April 1990 to May 1997**

| Location | Range | Average |
|---|---|---|
| P-10 area | 0.4-2.1 | 0.7 |
| N. Paguate | 0.6-<2.0 | 1.0 |
| OP-19 | 0.1-<2.0 | 0.8 |
| Geo Bldg | 0.7-1.9 | 1.2 |
| HIWAY | 0.7-2.0 | 1.2 |
| New Shop | 0.4-<2.0 | 0.6 |
| W. Paguate | 0.3-<2.0 | 0.9 |
| Well-6 | 0.3-1.8 | 1.2 |
| Paguate #1 | 0.3-1.2 | 0.7 |
| Paguate #2 | 0.3-2.2 | 0.5 |
| N. Jackpile | 0.3-1.4 | 0.7 |
| Old Shop | 1.1-2.5 | 1.5 |
| W. Jackpile | 0.4-2.9 | 1.8 |
| SW House | 0.4-1.5 | 0.8 |
| RMG-2 | 0.1-1.7 | 0.2 |

Average (all measurements) 1.0 pCi/L. Standard for the site is 3.5 pCi/L (3 pCi/L above background of 0.5 pCi/L)

## 6.0 DISCUSSION OF RESULTS

Gamma radiation on the mine reclamation areas was reduced by moving protore and surfaces of the contaminated areas into the pits and covering them with shale and topsoil. Waste dumps that had Jackpile Sandstone on the surface were also covered with topsoil.



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These activities effectively reduced measured gamma radiation to acceptable levels of less than 28 μR/hr on the mine areas up to, and during, 1993. There were no records of post-reclamation monitoring of gamma radiation after completion of reclamation in 1996.

All radon gas measurements were consistently below the standard limit of 3.5 pCi/L set by the ROD.

## 6.1 Data Condition

An evaluation of the gamma radiation and radon gas monitoring data is presented in Table 6-1.

**Table 6-1**
**Evaluation of Gamma Radiation and Radon Gas Monitoring Data**

| **Positives** | **Negatives** |
|---|---|
| Gamma Radiation | |
| • Most of the sites selected and measured were at the appropriate locations.<br>• The sample grids adequately covered the sites sampled.<br>• Using hand-held gamma meters was an excellent method for sampling areas. | • Recommendations for time periods to sample gamma radiation were not followed. There was no post-reclamation monitoring.<br>• Data was not summarized or presented in a form for analysis of results<br>• Data collected was not analyzed for patterns to determine when or where to monitor.<br>• Data was not in a well tabulated form and not checked for accuracy. |
| Radon Gas | |
| • Sampling periods and locations were adequate and followed the recommendations for monitoring and the EIS.<br>• Data was well recorded and summarized in tables.<br>• Data was easily analyzed for meeting standards. | • None |

## 6.2 Data Evaluation

The gamma radiation surveys were difficult to interpret, and in some instances incomplete. The survey data could have also been plotted on maps or in tables for analysis of patterns or trends.

In contrast, the radon gas measurements were mostly complete, summarized in tables, and easily interpreted in order to analyze for patterns and trends.

The Memorandum (dated May 20, 1994) from the BLM for a review of radiological monitoring stated that; 1) all reclamation personnel have received minimal dosages based on TLD badges, 2) results of the Track Etch® canisters for measuring radon are averaging 1.0 pCi/L, and 3) the gamma radiation in the revegetated North and South Paguate pit areas is equal to or less than background, and the gamma readings in backfilled and covered areas of the Jackpile pit are within the required reclamation limit of twice background.

## 7.0 CONCLUSIONS AND RECOMMENDATIONS

Based on this radiological measurement review, the following conclusions can be drawn:

1. The Jackpile Reclamation Project gamma radiation monitoring program deviated from the requirement of the Record of Decision in that results were not tabulated or analyzed, and were not continued for the specified time periods.
2. Gamma radiation levels are probably below the 28 μR/hr limit on most areas of the reclaimed mine site, but there is uncertainty due to the lack of recommended post-reclamation monitoring.
3. Radon gas levels were consistently below the limit of 3.5 pCi/L at all locations measured.

Based on these conclusions, the following recommendations can be made:

1. Gamma radiation levels should be checked in specific locations at least one more time to verify that reclaimed areas are meeting the standard of 28 μR/hr.
2. The reclaimed mine can be released from any requirement for radon gas measurements, and should present no hazards for human health.
3. Post-reclamation land uses can be instituted based on this radiation data evaluation.

## 8.0. REFERENCES

Jacobs Engineering Group, *Jackpile Project Environmental Monitoring Plan*, Final, 1989.

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Pueblo of Laguna, Reclamation Project Manager, *"Jackpile Reclamation Project, Pueblo of Laguna, New Mexico"*, Annual Report, 1996

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# JACKPILE-PAGUATE URANIUM MINE POST-RECLAMATION SOILS ANALYSIS AND HEAVY METAL AND RADIONUCLIDE UPTAKE IN VEGETATION ANALYSIS

## Table of Contents

## 1.0 INTRODUCTION

This report presents a soil evaluation and data review for the reclaimed Jackpile-Paguate Uranium Mine.

The objectives of this report are to:

1. Determine if the soils and vegetation testing met the requirements in the Jackpile-Paguate Reclamation Project Record of Decision (ROD) ($DOI_2$, 1986) as defined in the Environmental Impact Statement ($DOI_1$, 1986)
2. Review the soil and vegetations chemical and radiological data collected and applied topsoil depths during reclamation for requirements established in the ROD.
3. Make recommendations on how to overcome any ROD deficiencies.

## 2.0 BACKGROUND

The area of the mine and surrounding landscape is a region of broad mesas and plateaus separated by deep canyon, dry washes, and broad alluvial valleys on the southeastern edge Colorado Plateau province. This is a semi-arid region underlain by flat lying interbedded rock strata of Upper Cretaceous shale (Mancos) and associated sandstones (Tres Hermanos and Jackpile). Soils are predominantly shallow sandy loam to sandy clay loam on the mesas and slopes, and alluvial fine-grained deep soils in the valleys ($DOI_1$, 1986). Approximately 3.1 million cubic yards of topsoil materials (mostly crushed Tres Hermanos Sandstone) were stockpiled on the mine site and were used as topsoil during revegetation. In addition, a borrow area for topsoil of 44 acres was also utilized as needed. The revegetation project involved the filling of three open pits using protore (sub-grade ore) stockpiles, substrate materials from mine waste rock dumps, and covering with topsoil stockpiles.

Reclamation and revegetation techniques were first tested by the Anaconda Mining Company (AMC) starting in 1976, and continued on 11 additional waste piles in 1977, 1979, and 1980-1981 (Weston, 1991). The techniques AMC tested included topsoiling procedures based on soils analysis, seed mixtures, fertilization, and straw mulching. The results of the soil surveys on mine reclaimed waste dumps, stockpiled soils, and various locations within the mine site showed that all of the soil samples can be considered suitable plant growth media (Weston 1991). Soils from a few areas may have problems with permeability or salt content if used in isolation.

There was no site activity from 1982 to 1989. Final reclamation of the entire mine site started in 1990, and was completed at the end of 1996. The work involving topsoiling started in 1991 on waste dumps, and was continued on slopes and in pit bottoms until 1995.



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## 3.0 SOILS MONITORING AND ANALYSIS

Monitoring for soils was specified in Table 1-5 in the EIS as once prior to seeding. The proposed soils monitoring program is presented in Table 3-1. The ROD specified that the waste dumps with Jackpile Sandstone would be covered with 3 feet of overburden (generally Mancos Shale), and 18 inches of topsoil. Protore (Jackpile Sandstone, JPSS) used as backfill in pit areas would be covered with 3 feet of overburden, and 2 feet of Tres Hermanos Sandstone or alluvial material.

**Overview of Soil Reports** - Several documents present soil sampling results, and recommendations for use and need for monitoring before and after final reclamation. The Jacobs Environmental Monitoring Plan was designed to meet the specifics of the ROD and was, in fact, the approved plan that superceded the EIS table of recommendations. The Jacobs Environmental Monitoring Plan called for annual monitoring of salt in the pit bottoms for ten years, which would meet the requirements of the ROD; however, this monitoring was apparently not performed. The Soils and Vegetation Evaluation (Weston 1991) completed before reclamation started, indicates that no further soils testing should be required. The reports by Munk and Boden (Munk and Boden, 1996, 1997), which reported results of soils monitored after reclamation was complete, described soil profiles and characteristics in the pit bottoms, and provided discussion on potential for plant uptake from soils. There are no reports or records of soil being tested beyond the Munk and Boden reports of 1997.

**There were three types of soils testing discussed in documents associated with the Jackpile Reclamation:**

1) **testing for suitability for topsoil that could support revegetation goals,**
2) **testing for salt buildup that could reach concentrations toxic to plants and**
3) **testing of heavy metals and radiological compounds.**

**Table 3-1**
**Soils Testing Requirements Comparison**

| | EIS Table 1-5 | ROD | Jacobs Environmental Monitoring Plan | Actual |
|---|---|---|---|---|
| **Sampling Points** | One grid per 50 acres on each waste dump and pit bottom | Item 10: EIS Table 1-5 Unspecific | For Salt Buildup<br>NP Pit: 2 east, 2 west SP Pit: 2 east, 2 west Jackpile: 4 locations Half the locations in each pit will be in areas where ponding occurs after large precipitation events and half on well-drained areas. Sample collected from 3 to 9 inches below surface. Sampling points marked with 3 foot steel posts. | 1.) For Topsoil Suitability<br>Landmark/Weston (1991) collected 38 samples from 26 locations in the pit areas.<br>2.) No Salinity Sampling<br>3.) For Potential for Plant Uptake<br>Munk & Boden (1997) collected 12 samples |



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| | | | | |
|---|---|---|---|---|
| **Frequency** | Once Prior to Seeding | | Annually | 1.) Once<br>2.) Never<br>3.) Once |
| **Parameters** | U(natural), RA-226, Th-230, Se, Va, As, Cd, Mo, Pb, Zn | | EC of saturated paste extract | 1.) pH, EC, saturation %, Ca, Mg, Na, SAR, soil characteristics<br>2.) As, Cu, Mo, Pb, Se, Zn, Va, Pb-210, Po-210, Ra-226 |
| **Duration** | Once Prior to Seeding | | Begin after backfilling and continue for 10 years | 1.) Once<br>2.) Not Done<br>3.) Once |

## 3.1 Topsoil

The Jacobs Monitoring Report discusses soil testing to determine suitability for top dressing which was part of the reclamation operations and included in the construction specifications. It was not a part of the Long Term Post Closure Monitoring Program discussed in ROD Item 10. There are several reports which contain data on soils for suitability for top dressing.

a.) Landmark/Weston (1991)

In 1991, personnel from Weston collected and analyzed 38 soil samples from 26 locations in the South Paguate, North Paguate, and Jackpile areas. The soils sampled were analyzed for pH, EC, saturation percent, calcium, magnesium, sodium, sodium adsorption ratio, sand, silt, clay, and texture. These parameters were measured to determine the suitability of the soil to serve as top dressing over the Mancos Shale, and support growth of native species.

The results of the soil monitoring by Weston personnel (Landmark Reclamation/Weston, *"Jackpile Reclamation Project, Pueblo of Laguna, New Mexico, Soils and Vegetation Evaluation for Final Reclamation"*, Final, April 1991.) showed moderate soil parameters within normal ranges. Soils were moderately alkaline with a pH range of 7.3 to 8.2, low conductivity of 0.35 to 3.77 (with one sample to 5.37), and low sodium adsorption ratio (SAR) ranging from 0.11 to 1.13 (three samples were higher to 5.07), and textures from loam to sandy clay loam. Concerns raised by this study were the potential for high sodium content and low permeability soils. However, most soils had low clay content allowing salts to be leached. Other concerns were for high permeability with low water holding capacity; however, topsoiling materials were mixed and placed over shale, which compensates for high permeability. There were some areas showing potential revegetation problems that could not be attributed to soil conditions alone. The conclusion of this soils study was that the topsoiling material tested could support successful revegetation, and no further soils testing was necessary.

b.) Munk and Boden (1996, 1997)

The report on interim reclamation by Munk and Boden (1996) presented a table of soil characteristics for the cover materials in the pit bottoms from 6-foot deep pits. The parameters recorded were material depths, color, texture, percent fragments, effervescence, and rooting depths.

There is information in the abbreviated soils descriptions in the reports by Munk and Boden (1996, 1997) on soil depths and characteristics in three pit bottoms. One purpose of the soil investigation was to evaluate the general characteristics. Depths of topdressing ranged from 18 to 60 inches with an average depth of 30 inches; depths of shale ranged from 7 to 36 inches with an average of 21 inches. Textures were medium and varied from sandy loam to silty clay. The pH measured in this study ranged from 7.7 to 8.2, and EC ranged from 0.93 to 11.2. Soluble calcium was typically high from sulfate solid phases. The dark Mancos Shale layer is medium to fine texture with clay contents up to 45%. This shale was a mixed substrate with pH ranges from 3.5 to 7.8, and also had a high level of soluble calcium. The acid forming potential of the shale is limited as indicated by Acid Base Account evaluation.

c.) Miscellaneous Field Data Sheets

Field data sheets measuring shale and topsoil cover of waste dumps during 1991 and 1993 showed topsoil depths averaging 18 to 20 inches, and shale cover from 12 to 14 inches. No information was available on pit bottoms from these data sheets.

Suitability of topsoil dressing material was adequately measured prior to the start of reclamation. The soils were found to be suitable for revegetation, and further testing should not be required. This soils evaluation met the requirements of the ROD for monitoring soils once prior to seeding. The parameters measured were different from that specified by the EIS; however, the parameters measured identified the soils as suitable for plant growth.

The results of the soils monitoring showed varying depths of topsoil and overburden cover on the waste dumps and pit bottoms. There were two periods of measuring soil cover depths; 1) during construction on waste piles, and 2) post reclamation in the pit bottoms. The cover depths were adequate to provide growth media for plant growth and revegetation. Topdressing materials averaged 30 inches and shale overburden 21 inches for a total cover depth of 51 inches (4.25 feet). The ROD specified 3 feet of overburden, and 2 feet of topsoil for a total of 5 feet. The difference of 0.75 feet can be attributed to settling and compaction after soils were placed.

**Conclusion**

Overall, soils used for revegetation on the mine site were suitable for plant growth, and presented no problems for vigorous and productive vegetation communities. The reports on soils evaluation showed that the soil parameters were within normal ranges for local and native soils. Appropriate topsoil source areas were found and appropriate depths were laid down.

## 3.2 Salt Buildup

The ROD required salinity monitoring in the pits. The Jacobs Monitoring Plan directed the soils in the pits be monitored for salt buildup since a survey of drainages blocked by waste dumps showed the build-up of salts to levels toxic to plants in areas adjacent to the blockage. There were no data found regarding monitoring for salt in soils. No salinity in soils was monitored.

**Conclusion**

The ROD requirement to monitor salt buildup for impact to vegetation has not been met. Although visual inspection during reclamation and post reclamation does not indicate the presence of salinity induced stress in revegetated areas, a one time sampling and analysis of soils in areas adjacent blockages is recommended to verify this conclusion.

## 3.3 Radiologicals and Heavy Metals in Soils

The EIS Table 1-5 presents radiological and heavy metal parameters to be tested in soils from the dumps and pit bottoms, to assess potential for plant uptake. There was a one-time sampling of soils for chemical and radiological analyses. In September/October 1996 (Munk and Boden, 1997) 12 locations in the pit bottoms were sampled for soil parameters and characteristics after reclamation was complete, primarily for determining plant uptake of heavy metals and radionuclides. They sampled the topdressing (Tres Hermanos Sandstone TD), Mancos Shale (MS), and Jackpile Sandstone uranium protore (JPSS) layers. The constituents measured included arsenic (As), copper (Cu), molybdenum (Mo), lead (Pb), selenium (Se), zinc (Zn), vanadium (V); and the radionuclides lead-210 ($^{210}Pb$), polonium-210 ($^{210}Po$), and radium-226 ($^{226}Ra$).

The Munk and Boden (1997) reports that samples were taken at 12 locations within the pits for some radiological and heavy metals compounds. The reported results of soils monitored after reclamation was complete, provided discussion on the potential for plant uptake from soils. Their analysis of the soil topdressing, shale cover material, and protore in the pit bottoms indicated that the heavy metals, arsenic, copper, lead, molybdenum, and zinc occurred at typical levels for natural soils. They concluded that additional measurements of arsenic, copper, lead, molybdenum, and zinc were not warranted in the pit bottoms. However, the heavy metals, selenium and vanadium, and the radionuclides, radium-226, lead-210, and polonium-210, occurred at elevated levels in the Jackpile Sandstone protore. These metals and radionuclides have the potential for redistribution to the soil surface by vegetation, and should be monitored.

**Conclusion**

Because of the construction of barrier covers over the protore in the areas that had elevated metals and radionuclide, concentrations, those areas should be of no concern. The ROD requirement for monitoring was met for soil testing.

## 4.0 Plant Uptake Monitoring and Analysis

The EIS recommended several reclamation and revegetation activities that were intended to reduced the potential for vegetation uptake of metals and radionuclides or prevent grazing. The activities included:

1. Moving stockpiled protore (Jackpile Sandstone) into the pits and covering with overburden (Mancos Shale) and topsoil (Tres Hermanos Sandstone) before seeding for revegetation.
2. Covering exposed surfaces of Jackpile Sandstone on waste dumps with overburden and topsoil.
3. Clearing and moving contaminated materials from facilities, roads, rail spur, and disturbed sites; and topsoiling all disturbed sites (old roads, etc.) before revegetation.
4. Stabilizing slopes of waste dumps and pit highwalls.
5. Fencing pit bottoms (to prevent access of domestic cattle and human entry).

There was no site activity from 1982 to 1989. Final reclamation of the entire mine site started in 1990, and was completed at the end of 1996. Monitoring for vegetation uptake started with soils investigation in 1996 and continued with vegetation monitoring until 2006.

Requirements of the ROD and EIS, concerning monitoring for heavy metals and radionuclides uptake, were specified in Table 1-5 in the EIS. Table 4-1 presents the proposed and actual monitoring for vegetation uptake.

**Table 4-1**
**Comparison of Monitoring Requirements for Radionuclide and Heavy Metal Uptake Into Vegetation Comparison**

| | EIS Table 1-5 | ROD | Jacobs Environmental Monitoring Plan | Actual |
|---|---|---|---|---|
| **Sampling Points** | Transects on selected reclaimed waste dumps and all pit bottoms | Item 12: EIS Table 1-5, minimum 10 years following reseeding | One location per dump with JSS on outer surface | Pit Bottoms |
| **Frequency** | Annually | | Annually | 2001,2003, 2005, 2006 |
| **Parameters** | U(natural), RA-226, Po-210, Th-230, Se, V, As, Cu, Cd, Mo, Pb, Zn | | Edible Fraction for Ra-226, Po-210, Pb-210, Se, Va, As, Mo, Pb, Cu, Zn | As, Cu, Pb, Mo, Se, V, Zn, Pb-210, Po-210, Ra-226 |
| **Duration** | A minimum of 10 years following reclamation | | Commence one year after reseeding for a minimum of 10 years following reclamation. Increase locations if the trends indicate that toxic levels are being approached. | |

**Overview of Uptake Reports** Two documents in addition to the ROD and EIS dealt with the proposed vegetation uptake monitoring program after final reclamation.

a.) Jacobs, 1989

The Jacobs Environmental Monitoring Report reports that early data sets showed that *"vegetation on the disturbed areas is not accumulating heavy metals or radionuclides in concentrations that are toxic to livestock"*, but that it would be prudent to monitor to see if uptake changed with time. The monitoring plan proposed by Jacobs Engineering (Jacobs 1989) suggested annual monitoring begin one year after seeding and continue for 10 years. Thorium-230 was not included in the monitoring plan due to a low uptake factor, and Uranium (total) was also not included because of low plant uptake and a low conversion factor for the ingestion pathway. Instead, Polonium-210 was considered to have a greater potential human exposure pathway through ingestion, and was included in the monitoring that was implemented.

b.) Miscellaneous Data Sets

There were four years (2001, 2003, 2005, and 2006) in which vegetation was clipped and analyzed for heavy metals and radionuclides. The following metal and radionuclides were analyzed during these time periods:

1. June 2001, May 2003 and June 2005: heavy metals - As, Cu, Mo, Pb, Se, V, and Zn; radionuclides - $^{226}Ra$, $^{210}Po$, and $^{210}Pb$.
2. September 2006: heavy metals - As, Cu, Mo, Pb, Se, V, and Zn; and radionuclides were analyzed.

The results of the vegetation uptake monitoring are presented in Table 4-2. The results presented are the range of values, number of non-detects or negative values, and the average value for each time period. The following summarizes the values for each metal and radionuclide.

The following presents a discussion of these data sets.

METALS

Arsenic: The average concentrations were low at 0.2 to 0.4 mg/Kg, with many non-detects. One maximum concentration at 5.0 mg/Kg was recorded, but no discernable trend was observed during the 5-year monitoring period

Copper: This metal was detected in all vegetation samples at low average concentrations of 2.4 to 2.9 mg/Kg. There was one value of 7.6 mg/Kg, but there was no increase or trends noted during the sampling periods.

Lead: The average concentrations were low at 0.1 to 0.4 mg/Kg, with many non-detects. There was one value at 4.0 mg/Kg, but no trends were noted.

Molybdenum: The average concentrations were low at 0.2 to 0.5 mg/Kg, with many non-detects. There was one value at 3.7 mg/Kg, but no trends were noted.

Selenium: The concentrations varied from 0 to a maximum value of 42.9 mg/Kg. The concentrations measured in 2006 had increased in average value in the 2006 samples to 6.4 mg/Kg due to uptake by a perennial shrub (four-wing saltbush).

Vanadium: The concentrations were low averaging 0.6 to 1.5 mg/Kg with many non-detects

Zinc: The concentrations were consistent in all plants sampled varying from 3 to 47 mg/Kg. Average values were 14 to 20 mg/Kg, with no trends in the years sampled.

Measured uptake concentrations of metals into vegetation were either below, or within, normal ranges for all heavy metals analyzed. As discussed by Munk and Boden (1997), the potential for uptake by most plants is minimal given the soil properties in the pit bottoms. This was confirmed by the four growing seasons (2001 to 2006) of vegetation sampled and analyzed for heavy metals (see Table 5-1, and discussion of concentrations in plant species sampled). There was some concern by Munk and Boden (1997) that selenium and vanadium may accumulate on the surface and be translocated from the Jackpile Sandstone backfilled and covered in the pit bottoms. However, there was no increasing trend of these two metals measured in the vegetation eleven years after revegetation was complete.

The concentration in one shrub (four-wing saltbush) analyzed for selenium was within a normal high range, and may indicate that this shrub species is a secondary accumulator.

This species is a member of the goosefoot family, and is not generally grazed by domestic livestock when other more palatable grass species are available.

Domestic livestock can graze the grass/shrub vegetation in the pit bottoms without toxic effects from heavy metals. Selenium was the only metal found to have the potential for sub-acute toxicity in one sample in one shrub species that is generally not browsed by livestock. It is recommended that heavy metals monitoring should not be required in the future based on the sample results to date.

RADIONUCLIDES

Lead-210: The concentrations measured in vegetation were consistently low at less than 1 pCi/g (range 0 to 1.1) with some non-detects, and averaging 0.07 to 0.50 pCi/g. There was no increasing or decreasing trend in uptakes measured
Polonium-210: The concentrations measured in vegetation were also consistently low at less than 0.4 pCi/g (range 0 to 1.16) with some non-detects, and averaging 0.05 to 0.28 pCi/g. There was a slight increase in uptakes measured in 2006 (1.16 pCi/g) due to values in perennial shrubs (four-wing saltbush), and one grass sample.
Radium-226: The concentrations measured in vegetation were generally low at less than 1 pCi/g (range 0.002 to 2.1) with some non-detects, and averaging 0.17 to 0.72 pCi/g. There was no increasing or decreasing trend in uptakes measured

The concentration levels of radionuclides in the plant samples analyzed were uniformly low with no increasing trends in levels over the four periods vegetation was sampled. The concentration levels are well below values that are considered toxic to domestic livestock or wildlife; therefore, sampling of radionuclides should not be required in the future.

**Table 4-2**
**Summary of Results of the Heavy Metal and Radionuclide Vegetation Uptake Monitoring for the Jackpile Reclamation Project.**
**Results are in mg/Kg (ppm) for metals, and pCi/g (picocuries per gram) for radionuclides.**
***ND – non-detects or minus values**

| Year | 2001 – 15 Samples | | | 2003 – 10 Samples | | | 2005 – 39 Samples | | | 2006 – 16 Samples | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Metals | Range | ND* | Avg | Range | ND | Avg | Range | ND | Avg | Range | ND | Avg |
| As | 0-0.8 | 13 | 0.2 | - | 10 | - | 0-5.0 | 10 | 0.8 | 0-3.3 | 12 | 0.4 |
| Cu | 1.1-4.0 | 0 | 2.5 | 1.3-4.7 | 0 | 2.4 | 1.4-3.8 | 0 | 2.5 | 1.9-7.6 | 0 | 2.9 |
| Pb | 0-1.3 | 13 | 0.1 | 0-1.8 | 8 | 0.02 | 0-4.0 | 25 | 0.4 | 0-2.2 | 12 | 0.4 |
| Mo | 0-2.1 | 12 | 0.2 | 0-3.7 | 9 | 0.4 | 0-3.3 | 6 | 0.4 | 0-3.1 | 8 | 0.5 |
| Se | 0.94 | 9 | 1.5 | 0-5.3 | 3 | 0.9 | 0-5.3 | 9 | 1.4 | 0.5-42.9 | 0 | 6.4 |
| V | 0-3.7 | 9 | 0.6 | 0-4.8 | 7 | 0.6 | 0-8.1 | 28 | 0.7 | 0-19.1 | 13 | 1.5 |
| Zn | 9-47 | 0 | 20 | 8-29 | 0 | 15 | 3-34 | 0 | 18 | 8-25 | 0 | 14 |
| Radio-nuclides | | | | | | | | | | | | |
| $^{210}Pb$ | 0.1-1.9 | 0 | 0.44 | 0-1.12 | 1 | 0.50 | 0-0.3 | 14 | 0.07 | 0-0.87 | 4 | 0.28 |
| $^{210}Po$ | 0-0.5 | 5 | 0.17 | .03-.34 | 0 | 0.12 | 0-0.2 | 2 | 0.05 | .02-1.16 | 0 | 0.28 |
| $^{226}Ra$ | 0-0.5 | 5 | 0.17 | 0.2-0.5 | 0 | 0.38 | 0-2.1 | 2 | 0.72 | .002-.51 | 1 | 0.19 |

## Conclusions

Based on this vegetation uptake review, the following conclusions can be drawn:

1. The Jackpile Reclamation Project vegetation uptake-monitoring program deviated from the requirement of the ROD in that heavy metals and radionuclides were not measured for ten consecutive years after reclamation was completed.
2. Vegetation had low levels of metal and radionuclide uptake based on sampling and laboratory analysis. However, it should be noted that the uptake data collected was poorly documented and not analyzed or checked for concentrations or trends.
3. Vegetation growing on the reclaimed mine presents a minimal potential for hazards to domestic livestock or human health due to the low or normal concentrations of metals and radionuclides.
4. There is a semi-permanent surface water feature in the North Paguate pit. This area was not sampled for vegetation uptake. The vegetation around that pit should be monitored to determine if it is consistent with the vegetation uptake in the dry areas.

## Recommendations

1. Vegetation on the reclaimed mine appears to be stable and should not require further general testing or monitoring for heavy metals or radionuclides, with the exception of the area near the North Paguate surface water feature.
2. The reclaimed mine can be released from the vegetation monitoring requirements and should not require future monitoring.
3. Based on this vegetation uptake evaluation, post-reclamation land uses can be initiated.
4. It is possible that some additional specific vegetation analysis may be required based on a future surface water sampling program.

## 5.0 Data Condition

An evaluation of the soils monitoring data and vegetation uptake monitoring data is presented in Tables 5-1 and 5-2, respectively.

**Table 5-1**
**Evaluation of Soils Monitoring Data**

| Positives | Negatives |
|---|---|
| • Reports were clear and concise, and presented adequate detail.<br>• Survey and analytical methods were adequately explained.<br>• Reports were consistent for topsoil | • Soil depths were not consistently measured across the mine sites.<br>• Soil suitability was not measured immediately prior to seeding.<br>• Soil parameters required by the EIS were |

| | |
|---|---|
| suitability for revegetation<br>• Depths of topsoil and overburden placed averaged just below the required depth due to settling. | not analyzed until reclamation was complete.<br>• There was no discussion or evaluation of the soil data for suitability based on heavy metals or radionuclides.<br>• The required monitoring of salt build-up was not performed |

**Table 5-2**
**Evaluation of Vegetation Uptake Monitoring Data**

| Positives | Negatives |
|---|---|
| • All heavy metals and radionuclides were sampled during each time period.<br>• Sampling and laboratory analytical methods were adequately explained.<br>• The early monitoring plan and soils investigation report were well written and consistent. | • Recommendations for which metals to analyzed were not followed.<br>• Vegetation was not sampled for the 10-year period required by the EIS.<br>• Data collected was not analyzed for trends to determine which constituents should be continually monitored.<br>• Data was in a poorly tabulated form and not checked for accuracy. |

The review and analysis of the vegetation uptake data was difficult due to the poorly organized and presented data sheets, which had no periodic evaluation. An early sampling in 1997 or 1998 could have resulted in no need to sample for several of the metals as suggested by Munk and Boden (1997). An evaluation of the first three sampling periods in 2001, 2003, and 2005 would have shown that sampling for any metals or radionuclides in 2006 may not have been necessary.

## 6.0. REFERENCES

Jacobs Engineering Group, Inc., *"Jackpile Project, Final Environmental Monitoring Plan"*, August 1989.

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U.S. Department of the Interior, Bureau of Land Management and Bureau of Indian Affairs, *"Jackpile-Paguate, Uranium Mine Reclamation Project, Record of Decision"*, December 1986.

Field Data Sheets - Shale Cover and Top Soil Cover depths, 1991, 1993

Vegetation uptake measurements in data sheets (Excel or pdf) for heavy metals and radionuclides, 2001, 2003, 2005, and 2006.

# JACKPILE-PAGUATE URANIUM MINE
# POST-RECLAMATION
# WATER QUALITY DATA REVIEW

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## 1.0 INTRODUCTION

The following presents a review of the post-reclamation water quality monitoring and data for the Jackpile-Paguate Uranium Mine located on the Laguna Indian Reservation, Cibola County, New Mexico (see Figure 1-1). Please note that this analysis was prepared in the Fall of 2006, prior to receipt of the 2006 and 2007 water quality data and prior to the installation and sampling of two wells in the Jackpile Pit. Please see the attached addendum for these data analyses.

The objectives of this report are to:

1) Determine if the post-reclamation water quality monitoring has met the requirements as defined in the Jackpile-Paguate Reclamation Project Environmental Impact Statement ($DOI_1$, 1986) and the associated Record of Decision (ROD) ($DOI_2$, 1986).
2) Examine the water quality data collected as to its validity and its applicability in assessing long-term risks to people and the environment.
3) Define contaminants of concern and trends of these data.
4) Make recommendations as to future monitoring programs and steps that should be taken to ensure the health and safety of nearby residents.

The following presents a brief overview of the hydrology of the site and importance of the overall water quality monitoring program, as well as addressing each of the objectives outlined above.

## 2.0 BACKGROUND

The Jackpile-Paguate Uranium Mine was operated between 1953 and 1980. The mine consisted of three open pits (the Jackpile, North Paguate, and South Paguate) and a series of underground workings. The pits were between 200 and 300 feet deep with the mine and associated facilities within a 7,868 lease area, of which approximately 3,140 acres of land was reclaimed. A little less that 1/3 of this disturbed acreage was reclaimed prior to 1980 by the Anaconda Copper Company, which operated the mine.

In December 1986, under a series of agreements between the Bureau of Indian Affairs and the Pueblo of Laguna, it was agreed that the Pueblo of Laguna would perform the management, coordination and administration of the Jackpile-Paguate Reclamation Project in accordance with the requirements set forth in the Jackpile-Paguate Reclamation Project Environmental Impact Statement ($DOI_1$, 1986) and the associated Record of Decision (ROD) ($DOI_2$, 1986). This project involved the reclamation of the three open pits, 32 waste dumps, 23 protore (sub-grade ore) stockpiles, four topsoil stockpiles, as well as roads and buildings on the remaining 2,656 acres of disturbed land. As defined in the ROD, the objectives of the reclamation are:

1) To ensure human health and safety.

2) To reduce the release of radioactive elements and radionuclei to as low as reasonably achievable.
3) To ensure the integrity of all existing cultural, religious and archeological sites.
4) To return the vegetative cover to a productive condition compatible with the surrounding area.
5) Provide for additional land uses that are compatible with other reclamation objectives and that are desired by the Pueblo of Laguna.
6) Eliminate the need for post-reclamation maintenance.
7) Blend the visual characteristics of the mines with the surrounding terrain.
8) Employ the Pueblo of Laguna people in efforts that afford them opportunities to utilize the skills or train them as appropriate.

An important aspect of the EIS and the ROD is gaining a thorough understanding of the hydrogeology and surface water hydrology of the site. Much has been written about the hydrology of the site. Dames and Moore (1980), Hydro Geo Chem (1982), Zehner (1985), and others have presented detailed descriptions of the aquifers and surface water drainages at the mine site. It is suggested that the reader review the EIS for additional information of the overall hydrology of the site. This information was utilized to develop an environmental monitoring plan for the Pueblo of Laguna (Jacobs Engineering Group Inc., 1989). This monitoring plan, which will be discussed later in more detail, covered the monitoring of groundwater in the Jackpile Sandstone which is the principle aquifer underlying the site, the alluvium, and the fill in the pits as well as the surface waters in the Rio Moquino and Rio Paguate which receive runoff from the site.

## 3.0 MEETING THE REQUIREMENTS OF THE ROD AND EIS

As mentioned earlier, one of the objectives of this report is to determine if the post-reclamation has met the water quality monitoring requirements of the EIS and the ROD. In Table 1-5 (Summary of Proposed Monitoring Programs) of the EIS for the Preferred Alternative it was suggested that the following water quality monitoring program be implemented, which is presented in Table 3-1.

**Table 3-1**
**Proposed Water Quality Monitoring as Presented in the EIS ($DOI_1$, 1986)**

| Item | Proposed Water Quality Monitoring for Proposed Alternative | |
|---|---|---|
| Surface Water Quality | **No. of Stations** | 7 |
| | **Parameters** | Group A: pH, EC, temperature, Bicarbonate Chloride. Sulfate, Sodium, Silicon dioxide, Magnesium, Nitrate, Manganese, Iron, Uranium (natural) and Radium 226 Group B: Same as Group A with Arsenic, Boron, Barium, Cadmium, cyanide, Cobalt, Chromium, Copper, Fluoride, Mercury, Molybdenum, Nitrogen, Lead, Phosphate, Selenium, Vanadium, Zinc, and Ra228 |
| | **Frequency** | Quarterly for Group A and Semi-annually for Group B |
| | **Duration** | During reclamation and 10 years thereafter. |
| Groundwater | **Number of Wells** | 17 |
| | **Parameters** | Group A: pH, EC, temperature, Bicarbonate Chloride. Sulfate, Sodium, Silicon dioxide, Magnesium, Nitrate, Manganese, Iron, Uranium (natural) and Radium 226 Group B: Same as Group A with Arsenic, Boron, Barium, Cadmium, cyanide, Cobalt, Chromium, Copper, Fluoride, Mercury, Molybdenum, Nitrogen, Lead, Phosphate, Selenium, Vanadium, Zinc, and Ra228 Plus water levels |
| | **Frequency** | Semi-annually fro Group A and Annually for Group B |
| | **Duration** | During reclamation and 10 years thereafter |

In the ROD ($DOI_2$, 1986), monitoring requirements were stated as follows:

*"The monitoring period will vary for each parameter. Existing monitoring activities to be continued will include: meteorologic sampling, air particulate sampling, radon sampling (ambient)………water monitoring and subsidence. The monitoring program will be expanded to include: radon daughter levels (working levels) in any remaining workings and ground water recover levels/salt build-up in the open pits. The ground water monitoring period will be of sufficient duration to determine the stable future water table conditions. Refer to Table 1-5 of the FEIS for details of the monitoring plan as described under the Preferred Alternative."*

The following presents the proposed and applied water quality monitoring programs for groundwater and surface water.

## 3.1 Groundwater

In the Final Approved Environmental Monitoring Plan (Jacobs Engineering Group Inc., 1989), the monitoring program proposed in the EIS was somewhat modified. For groundwater, it was recognized that the potential for groundwater contamination is one of the "most sensitive" issues to the public. Based on groundwater studies by numerous consultants, it was determined that contaminated water has not migrated offsite and that the open pits act as groundwater sinks, and potential for groundwater to move offsite would not occur for some time. In this plan, it was recommended that five wells be completed in the Jackpile Sandstone, four wells in the alluvium, six wells in the pit backfill and two additional locations to be selected. Table 3-2 presents the Jacobs Environmental Monitoring Plan preferred locations of these wells. With the initiation of monitoring, a total of eight wells were completed with four wells in the Jackpile Sandstone, four wells in the alluvium, and four wells in fill material. Details for these wells are presented in Table 3-3 and illustrated in Figure 3-1. Fewer wells were installed than proposed in the Jacobs Environmental Monitoring Plan and the upgradient well for the SP Pit area (MW-8) collapsed in 1991 and was never replaced. The actual monitoring program is deficient in that it lacks two wells in the Pit and lacks a well downgradient of the Jackpile Pit in the Jackpile Sandstone formation. One of the two downgradient wells, MW-2 or MW6, was supposed to be placed in the Jackpile Sandstone formation, however, both are in the alluvium. Reportedly, the Jackpile Sandstone is not present at the downgradient boundary.

**Table 3-2**
**Proposed Wells Locations in the Environmental Monitoring Plan (Jacobs Engineering Group, 1989)**

| Location | Formation for Completion |
|---|---|
| GROUP A | |
| Southwest of South Paguate Pit (background well) | Jackpile Sandstone |
| North of North Paguate Pit (background well) | Jackpile Sandstone |
| North-northeast of Jackpile Pit (background well) | Jackpile Sandstone |
| North of the Rio Paguate and west of the Rio Moquino near the confluence | Alluvium |
| South of the Rio Paguate and north of the South Paguate Pit | Alluvium |
| South of the Jackpile Pit offices and east of the Rio Paguate | Alluvium |
| In Oak Canyon adjacent to the designated site boundary | Jackpile Sandstone |
| Near the Intersection of the south end of the designated site boundary and the Rio Paguate | Jackpile Sandstone |
| Near the intersection of the south end of the designated site boundary and the Rio Paguate | Alluvium |
| GROUP B | |
| In the North Paguate Pit after backfilling | Fill |
| In the North Paguate Pit after backfilling, west thumb | Fill |
| In the South Paguate Pit after backfilling, SP-20 pit | Fill |
| In the main South Paguate Pit after backfilling | Fill |
| In the central portion of the Jackpile Pit after backfilling (2 wells) | Fill |
| GROUP C | |
| Two location to be selected by the Pueblo of Laguna and Department of Interior[1] | |
| [1] More wells may be required if the migration of contaminated groundwater off the site is detected by the proposed monitoring wells. | |

**Table 3-3**
**Groundwater Monitoring Well Locations and Completion Information**

| Well Number | Location | | Total Depth (ft) | Description | Formation |
|---|---|---|---|---|---|
| | Northing | Easting | | | |
| MW-1 | 1506790 | 639458 | 231 | North of N. Paguate Pit | Jackpile SS |
| MW-2 | 1500707 | 648932 | 40 | Near the Intersection of the south end of the designated site boundary and the Rio Paguate | Alluvium |
| MW-3 | 1504131 | 643052 | 60 | South of the Jackpile Pit offices and east of the Rio Paguate | Alluvium |
| MW-4 | 1503734 | 639392 | 50 | South of the Rio Paguate and north of the South Paguate Pit | Alluvium |
| MW-5 | 1494714 | 648687 | 262 | In Oak Canyon adjacent to the designated site boundary | Jackpile SS |
| MW-6 | 1495801 | 650527 | 60 | Near the intersection of the south end of the designated site boundary and the Rio Paguate | Alluvium |
| MW-7 | 1511275 | 647255 | 375 | North of the Rio Paguate and west of the Rio Moquino near the confluence | Jackpile SS |
| MW-8 | 1500945 | 633094 | 456 | Southwest of South Paguate Pit (collapsed) | Jackpile SS |
| SP-OP-34 | 1500641 | 637929 | na | In the South Paguate Pit after backfilling, SP-20 pit | Backfill |
| SP-OP-35 | 1501033 | 634954 | na | In the main South Paguate Pit after backfilling | Backfill |
| NP-OP20W | 1504824 | 638746 | na | In the North Paguate Pit after backfilling, west thumb | Backfill |
| NP-OP20E | 1505123 | 641582 | na | In the North Paguate Pit after backfilling | Backfill |

In the Environmental Monitoring Plan, it was recommended that groundwater samples be analyzed for the following parameters:

- Water Levels
- pH
- Specific Conductivity
- Temperature
- Total Dissolved Solids
- Sulfate
- Molybdenum
- Vanadium
- Selenium
- Uranium (Total)
- Gross Alpha
- Lead-210
- Polouium-210
- Radium-226

Analysis of the following parameters, on a one time basis after reclamation is completed, was also recommended.

- Bicarbonate
- Chloride
- Calcium
- Sodium
- Sodium
- Silicon dioxide
- Magnesium
- Nitrates
- Nitrite
- Manganese
- Arsenic
- Barium
- Cadmium
- Cyanide
- Chromium
- Fluoride
- Mercury
- Lead
- Phosphorus
- Potassium
- Selenium
- Silver
- Zinc

In addition, on a one time basis after reclamation had been completed, organic substances including halogenated volatile organics (EPA Method 601), aromatic Volatile organics (EPA Method 602) and base/neutral, acid extractables, and pesticides (EPA Method 625) were to be analyzed.

Final groundwater monitoring between 1989 and 1994 consisted of semi-annual monitoring of each of the monitoring wells with the exception MW-8, which collapsed and was abandoned. Samples were taken in April/May and in November/December. The parameter list consisted of both sets of parameters recommended by the Environmental Monitoring Plan. During post-reclamation (1995 – present), monitoring consisted of annual sampling of MW-1 through MW-7 and the four pit wells for the same list of parameters. Sampling took place during April/May of each year. At the time of this review, water level information was only available on a semiannual basis between May 1992 and November 1994.

## 3.2 Surface Water

According to the Environmental Monitoring Plan (Jacobs Engineering Group, 1989), surface water studies by consultants for various organizations indicate that the mine site does not appreciably contribute to contamination of the Rio Moquino and the Rio Paguate. According to the plan, surface water samples were to be taken quarterly at each of the seven stations listed in Table 3-4.

**Table 3-4**
**Proposed Surface Water Monitoring Locations in the Environmental Monitoring Plan**

| Location |
|---|
| Upstream on the Rio Moquino |
| Rio Moquino above the confluence |
| Upstream on the Rio Paguate |
| Rio Paguate above the confluence |
| Rio Paguate below the confluence |
| Rio Paguate – Ford Crossing |
| Each major pond in the open pits |

Samples taken from these sites were to be analyzed for total dissolved solids, gross alpha, and radium-226. Semi-annual samples were to be taken at each of the stations and analyzed for following parameters:

- pH
- Specific Conductivity
- Temperature
- Total Dissolved Solids
- Sulfate
- Molybdenum
- Vanadium
- Arsenic
- Selenium
- Uranium (Total)
- Gross Alpha
- Lead-210
- Polouium-210
- Radium-226

with the following parameters on a one time basis after reclamation is completed.

- Bicarbonate
- Chloride
- Calcium
- Sodium
- Silicon dioxide
- Magnesium
- Nitrates
- Nitrite
- Manganese
- Arsenic
- Barium
- Cadmium
- Cyanide
- Chromium
- Fluoride
- Mercury
- Lead
- Phosphorus
- Potassium
- Selenium
- Silver
- Zinc

With the initiation of monitoring, a total of seven surface water stations were monitored. These stations are listed in Table 3-5 and presented in Figure 3-1 and correspond with the six river sampling sites presented in the Environmental Monitoring Plan, plus the monitoring of Paguate Reservoir. The Jacobs Environmental Monitoring Plan required monitoring major ponded water in the open pits. This was not done. Surface water samples were analyzed for both sets of parameters recommended by the Jacobs Environmental Monitoring Plan on a semi-annual basis in April/May and

November/December between 1989 and 1994 and annually in April/May between 1995 and present.

**Table 3-5**
**Existing Surface Water Sampling Locations**

| Station | Location |
|---|---|
| RT | Rio Paguate – Ford Crossing – Rail Trestle |
| URP | Upper Rio Paguate - Upstream |
| LRP | Lower Rio Paguate above the confluence |
| URM | Upper Rio Moquino |
| LRM | Lower Rio Moquino |
| PM | Rio Paguate below the confluence |
| LAKE | Paguate Reservoir |

## 4.0 RESULTS

As part of this review, data was evaluated for the ten-year monitoring period between 1996 and 2006. These analyses were completed by Hall, Assagai, or American Radiation Services. At the time of this report, complete analyses were not available for 2006. These results are presented in detail in Appendix A of the Water Quality Report. Highlighted in these data tables are those parameters which equal or exceed USEPA's (2002) Maximum Contaminate Levels (MCL) in light blue and National Secondary Water Quality Levels (NSWQL) in light gray. These exceedances will be discussed in Section 5 of this report. As part of the review process, the data were summarized in terms of count, mean, maximum, minimum, and median. An example of this data reduction is presented in Table 4-1. These results are also presented in Appendix A. Analytical methods used are summarized in Appendix B.

In addition to the field parameters, major cations and anions, nutrients, and trace metals, radionuclides and radioactive emissions were also analyzed. Radionuclides contain unstable nuclei and are said to be radioactive. This instability is manifested as the potential to decay or fall into a lower energy state by releasing principally either alpha or beta particles, or gamma rays. An alpha particle is defined as a positively charged particle consisting of two protons and two neutrons. A beta particle is either a negatively charged negatron/electron or a positively charged particle (positron). Gamma rays are high energy, short-wavelength electromagnetic radiation. Radioactive emissions are measured by an activity unit called a Curie (Ci), representing 3.7x1010 disintegrations per second.

## Table 4-1
## Example of Reduced Data Table as Presented in Appendix A

**GROUNDWATER MW-1**

| | Analyte | Units | Number | Mean | Maximum | Minimum | Median |
|---|---|---|---|---|---|---|---|
| Field Measurements | sample temperature @ | deg C | | | | | |
| | Conductivity | umhos/cm | 10 | 1938 | 2200 | 1060 | 2015 |
| | pH | units | 10 | 7.918 | 8.2 | 7.2 | 7.995 |
| Major Cations and Anions | Total Dissolved Solids | mg/L | 10 | 1256.8 | 1400 | 719 | 1300 |
| | Alkalinity, Bicarbonate | mg/L | 10 | 497.7 | 576 | 451 | 493.5 |
| | Alkalinity, Carbonate | mg/L | 10 | 2.82 | 6.2 | 2 | 2 |
| | Alkalinity, Total | mg/L | 9 | 501 | 576 | 451 | 498 |
| | Chloride | mg/L | 10 | 15.14 | 16.6 | 13.7 | 15.2 |
| | Sulfate | mg/L | 9 | 529 | 602 | 469 | 514 |
| | Calcium, dissolved | mg/L | 10 | 12.5 | 61.3 | 5.2 | 6.8 |
| | Magnesium, dissolved | mg/L | 10 | 5.8 | 39.2 | 1.8 | 2.2 |
| | Potassium, dissolved | mg/L | 10 | 2.4 | 3.3 | 1.9 | 2.2 |
| | Sodium, dissolved | mg/L | 10 | 520.3 | 889.0 | 423.0 | 486.0 |
| | Silica | mg/L | 3 | 4.9 | 5.4 | 4.7 | 4.7 |
| | Silica, as SiO2 | mg/L | 7 | 8.92 | 10.5 | 6.93 | 9 |
| Nutrients | Nitrate, as N | mg/L | 10 | 0.53 | 1.06 | 0.05 | 0.53 |
| | Nitrite, as N | mg/L | 10 | 0.15 | 0.9 | 0.05 | 0.05 |
| | Orthophosphate, as P | mg/L | 10 | 0.23 | 0.5 | 0.05 | 0.05 |
| Trace Metals | Arsenic, dissolved | mg/L | 10 | 0.00071 | 0.0012 | 0.0005 | 0.0006 |
| | Barium, dissolved | mg/L | 10 | 0.01144 | 0.0214 | 0.0095 | 0.01015 |
| | Cadmium, dissolved | mg/L | 10 | 0.0005 | 0.0005 | 0.0005 | 0.0005 |
| | Chromium, dissolved | mg/L | 10 | 0.0012 | 0.003 | 0.001 | 0.001 |
| | Cyanide, Total | mg/L | 10 | 0.01 | 0.01 | 0.01 | 0.01 |
| | Fluoride | mg/L | 10 | 2.322 | 2.66 | 2.02 | 2.4 |
| | Lead, dissolved | mg/L | 10 | 0.0065 | 0.0600 | 0.0005 | 0.0005 |
| | Lead-210 | pCi/L | 3 | 1.2506667 | 3.29 | 0.082 | 0.38 |
| | Manganese, dissolved | mg/L | 10 | 0.07492 | 0.721 | 0.0005 | 0.00315 |
| | Mercury | ug/L | 10 | 0.0202 | 0.2 | 0.0002 | 0.0002 |
| | Molybdenum, dissolved | mg/L | 10 | 0.006 | 0.009 | 0.002 | 0.006 |
| | Selenium, dissolved | mg/L | 10 | 0.0031 | 0.0080 | 0.0005 | 0.0028 |
| | Silver, dissolved | mg/L | 10 | 0.0005 | 0.0005 | 0.0005 | 0.0005 |
| | Vanadium, dissolved | mg/L | 10 | 0.0011 | 0.002 | 0.001 | 0.001 |
| | Zinc, dissolved | mg/L | 10 | 0.02501 | 0.1 | 0.005 | 0.00705 |

For drinking water, the common representation of activity is the Pico Curie (pCi), equal to 10-12 Ci. Parameter analyzed in water samples included:

- Gross alpha
- Gross beta
- Radium-226
- Lead-210
- Polonium-210

For these parameters a range is presented as +/-, this range basically represents background radiation or potential error within the 95-percentile. A negative value indicates that background is higher than the radiation emitted. Although important, when evaluating radionuclides and emissions, the error is ignored. Exceedances to standards are based on the determined value or concentration with negative values being neglected.

# 5.0 DISCUSSION OF RESULTS

## 5.1 Data Condition

As mentioned earlier, data were evaluated for the last 10 years – 1997 through 2006. It should be noted that there are complete data sets for years prior to 1997 but these ten years were considered the most appropriate for this evaluation. In the evaluation of these data sets, there were both positive and negative aspects as presented in Table 5-1. Overall, there appears to have been no effort to evaluate the data over the last ten years. Data was not organized, laboratory QC/QA was not analyzed, trends were not evaluated, and conclusions were not drawn as to the potential hazards groundwater or surface water posed to human health and the environment.

**Table 5-2**
**Evaluation of Post Reclamation Water Quality Data**

| Positives | Negatives |
|---|---|
| • Lab sheets were clear.<br>• Analytical methods were explained.<br>• Duplicate samples and QA/QC samples were identified<br>• Detection limits were for the most part satisfactory<br>• With a few exceptions, all parameters as suggested by the Environmental Monitoring Program were analyzed for each year<br>• Samples were collected consistently during the months of April and May for each year | • Data was disorganized.<br>• No effort was made by the laboratory or Reclamation Project to perform standard quality control and quality assurance processes.<br>• Data transfer to logical tables as presented in Appendix A was sometimes difficult and time consuming.<br>• It appears that no effort was made by the Reclamation project to review the data on an annual basis to evaluate trends and concerns.<br>• No Water quality standards were defined in the ROD, Monitoring Plan or EIS.<br>• No wells were installed in the Jackpile Pit.<br>• Ponded water in open pits was not sampled.<br>• No well in the Jackpile Sandstone formation near the downgradient boundary.<br>• Water Table Elevation Data were not available.<br>• Flow, although not required by the ROD would be helpful in understanding the surface water flow system. |

## 5.2 Water Characteristics

### 5.2.1 Groundwater

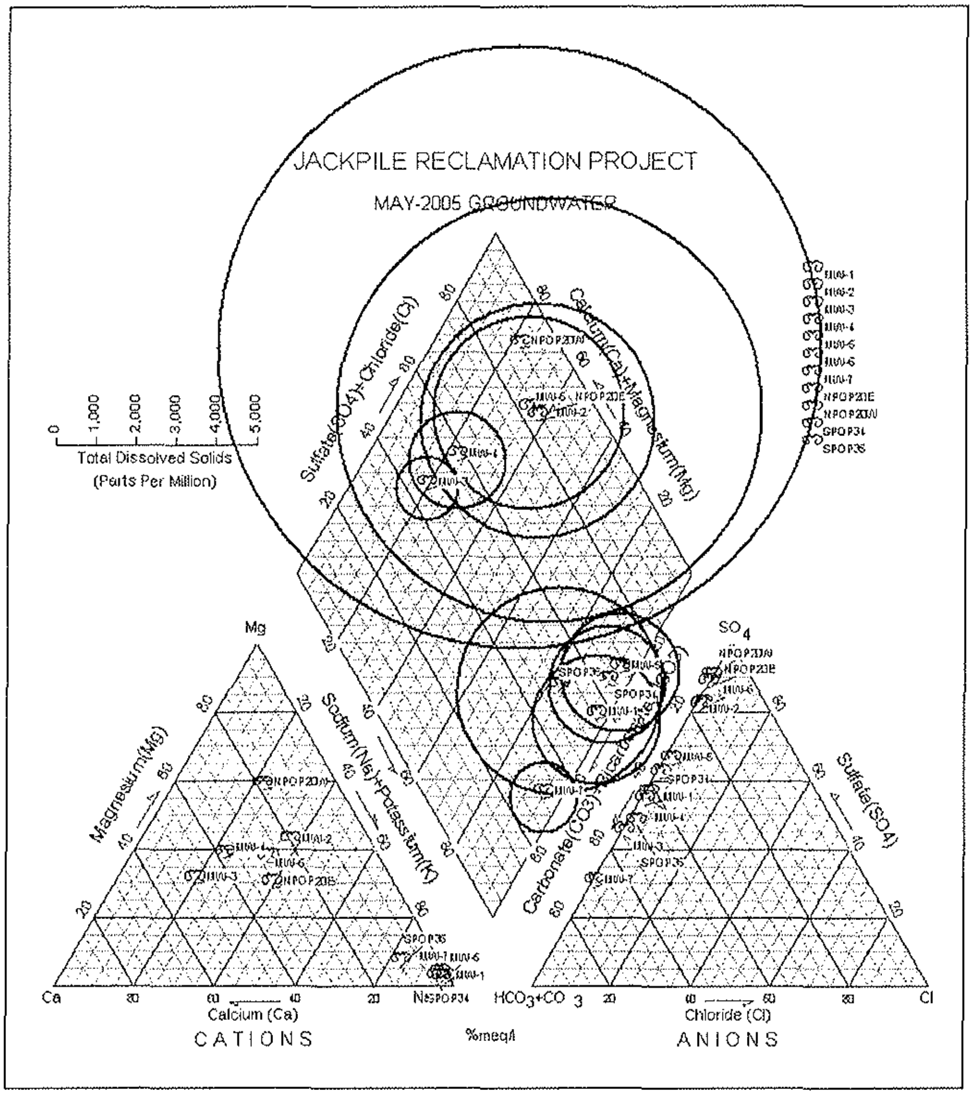
Hydro Geo Chem, Inc. did a complete evaluation of the hydrochemistry of the Jackpile-Paguate Mine in 1982. In their report, they concluded that groundwater at the mine site shows a chemical evolution from a calcium-sulfate to a sodium sulfate type. This is attributed to cation exchange along the groundwater flow path from the Zuni Uplift to the Pueblo of Laguna area. When the water enters the Rio Puerco Fault Zone it mixes with more saline waters upwelling from the Permian rocks. Zehner (1985) also evaluated groundwater at the mine site in 1985. His analysis indicated that well water that was in direct contact with clay and shale are dominated by sodium cations and bicarbonate/sulfate anions, whereas water from wells completed in more oxidized clay and shale are predominated by sodium – sulfate waters. Wells at the time of the Zehner (1985) study ranged in total dissolved solids between 900 and 1,500 mg/L.

Evaluation of groundwater quality data from the 2005 sampling (the last full set of data at the site) indicates that groundwater has evolved over time with sulfate in most cases being the predominate anion but with sodium being the predominate cation in pit wells (NPOP20E, SPOP-34, and SPOP-35) and in well water from MW-1, MW-5, and MW-7 which are completed in the Jackpile Sandstone. Wells completed in alluvium range from calcium-sulfate type water (MW-4) to calcium-bicarbonate water (MW-3) to magnesium--sulfate water in MW-6. These data are summarized in Table 5-1 and presented in Figure 5-1, which is a Piper Diagram illustrating the chemical analyses of water as percentages of total equivalent per liter. Total dissolved solids are also higher ranging between 671 mg/L (MW-3) and 8080 mg/L (NPOP20E).

**Table 5-3**
**2005 Groundwater Quality (Major Cation and Anion) Summary**

| Well Number | Aquifer | Total Dissolved Solids (mg/L) | Water Type | |
|---|---|---|---|---|
| | | | Predominant Cation | Predominant Anion |
| MW-1 | Jackpile SS | 719 | Sodium | Sulfate |
| MW-2 | Alluvium | 3200 | Magnesium | Sulfate |
| MW-3 | Alluvium | 671.05 | Calcium | Bicarbonate |
| MW-4 | Alluvium | 1069 | Calcium | Sulfate |
| MW-5 | Jackpile SS | 1359 | Sodium | Sulfate |
| MW-6 | Alluvium | 2460 | Magnesium | Sulfate |
| MW-7 | Jackpile SS | 665.91 | Sodium | Bicarbonate |
| NPOP20E | Fill | 5360.5 | Sodium | Sulfate |
| NPOP20W | Fill | 8080 | Magnesium | Sulfate |
| SPOP-34 | Fill | 1329 | Sodium | Sulfate |
| SPOP-35 | Fill | 2637 | Sodium | Carbonate? |

**Figure 5-1**
**Piper Diagram – 2005 Groundwater Jackpile-Paguate Reclamation Project**




Finally, trends in total dissolved solids in groundwater samples are quite variable. For observation wells outside the pit, total dissolved solids (TDS) generally have slightly decreased over the last ten years during post-reclamation as depicted for samples from wells MW-5 and MW-6. However, TDS in samples from alluvial wells MW-2 and MW-4 have gradually increased in TDS over time. These wells are located adjacent and down gradient from the pits. With the exception of SPOP34, samples for wells completed in fill material in the pits show a downward TDS trend. TDS levels in samples from SPOP34 are slightly increasing.

**Figure 5-2**
**Post Reclamation TDS Trends for Jackpile Paguate Observation Wells 1997 – 2006**

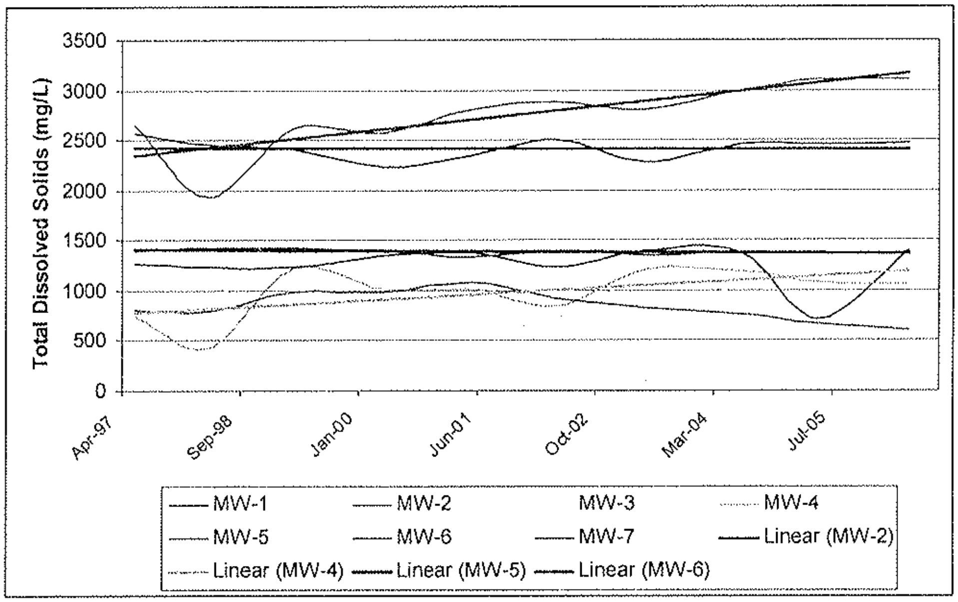
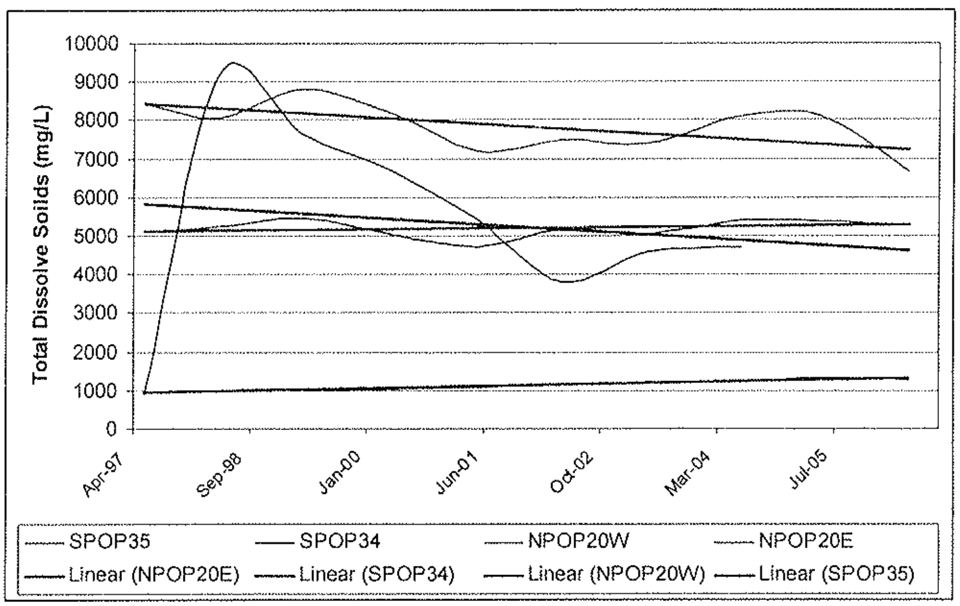



**Figure 5-3**
**Post Reclamation TDS Trends for Jackpile-Paguate Pit Wells - 1997 – 2006**

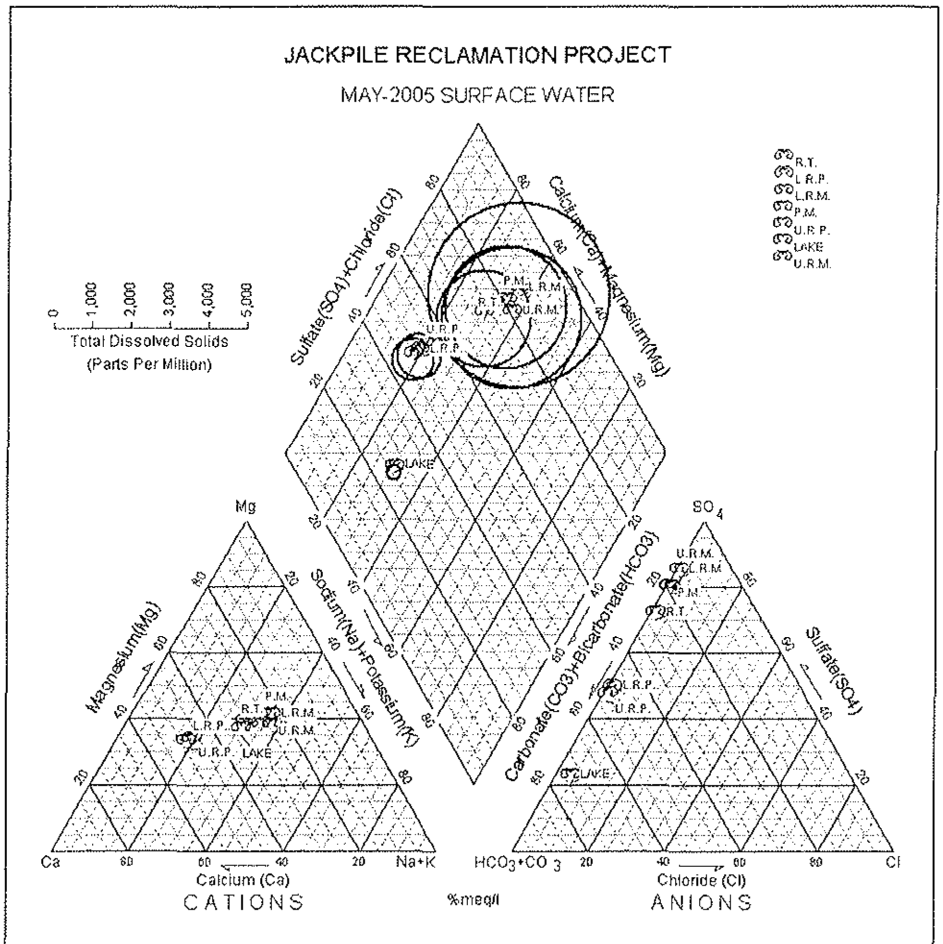



### 5.2.2 Surface Water

Zehner (1985) concluded that the Rio Moquino contains greater concentrations of dissolved solids than does the Rio Paguate. The mean dissolved solids concentrations at the time of the Zehner study in the Rio Moquino range from 1,600 mg/L upstream from the mine area to 1,900 mg/L just upstream from its confluence with the Rio Paguate. In the Rio Paguate the total dissolved solids increased to about 2,000 mg/L. The Rio Moquino contained calcium, magnesium, and sodium concentrations in nearly equal proportions and sulfate concentrations greater than bicarbonate or chloride.

Again, looking at the last full set of data from 2005 as illustrated in the Piper Diagram (Figure 5-4), there appears to be three types of water. Water samples from the Rio Paguate upstream from the mine (URP) and above the confluence (LRP) are calcium-magnesium-bicarbonate waters. Water samples from the Rio Moquino (URM, LRM) and at sampling stations on Rio Paguate below the confluence (PM) and at Ford Crossing (RT) are slightly more sodium rich with sulfate being the predominate anion.

**Figure 5-4**
**Piper Diagram for 2005 Surface Water Samples**




Total dissolved solids are somewhat higher than those reported by Zehner (1985) with TDS concentrations for the Rio Moquino ranging between 2,350 (URM) to 2,960 (LRM) and for the Rio Paguate concentrations ranging between 735 mg/L at URP to 2,110 below the confluence at station PM. In general, total dissolved solid concentrations appear to be cyclical in nature over the last 10 sampling periods for both the Rio Paguate (Figure 5-5) and the Rio Moquino (Figure 5-6). There does appear to have been a general decrease in total dissolved concentrations at all stations except Station URP upstream from the mine. Without flow data it is uncertain at this time as to dilution affects on these long term trends.

**Figure 5-5**
**Post Reclamation TDS Trends for the Rio Paguate - 1997 – 2006**

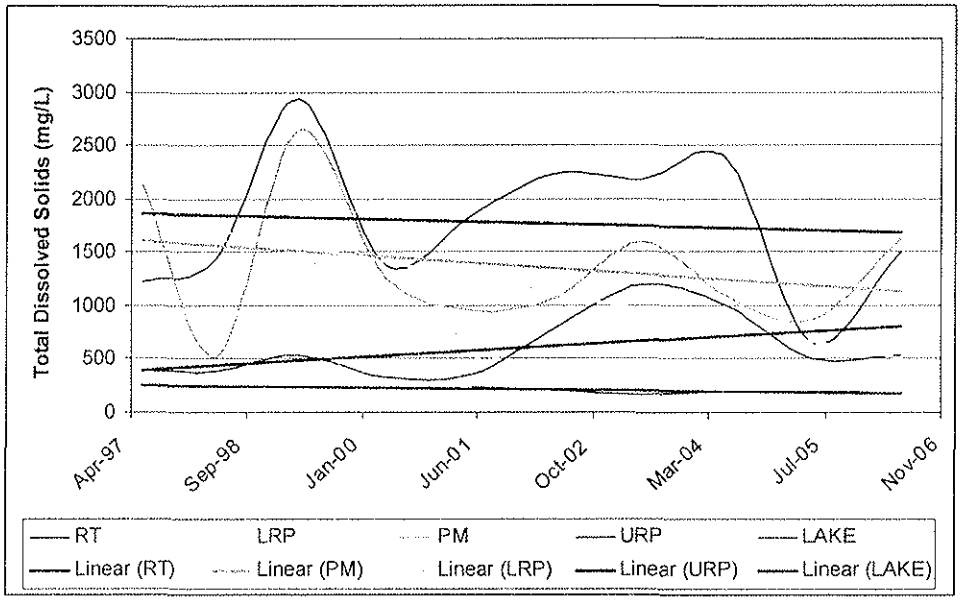
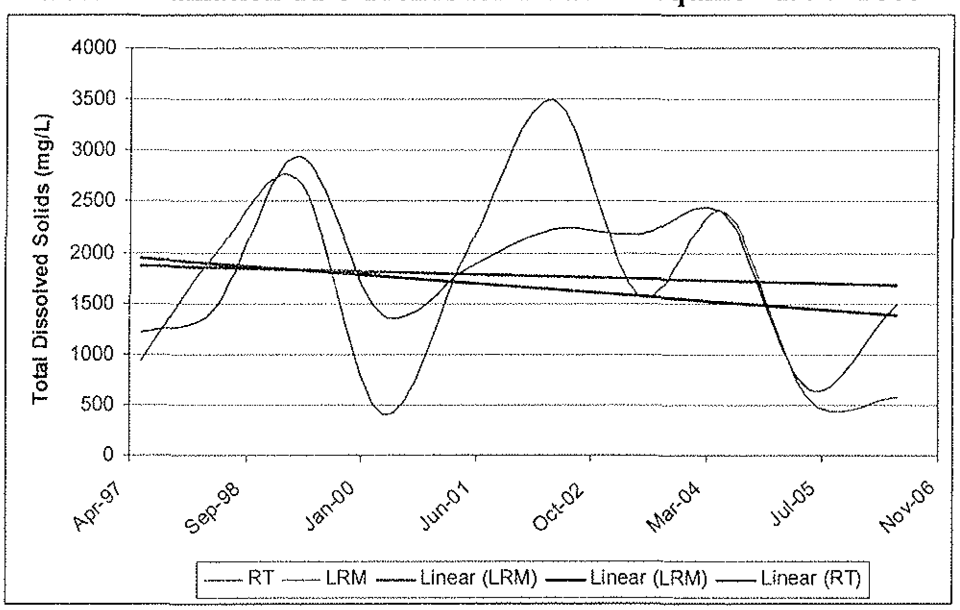



**Figure 5-6**
**Post Reclamation TDS Trends for the Rio Moquino - 1997- 2006**



## 5.3 Potential Hazards

### 5.3.1 Drinking Water

One of the major concerns of the Record of Decision is the potential for contamination of surface water and groundwater, due to the mining and reclamation operation, to affect human health and post-reclamation land use. In 1989, a study of water quality in ponds in the open pits indicated that water exceeded national primary drinking water standards for uranium and radium, and secondary drinking water standards for total dissolved solids and sulfate, and could not be released into the Rio Paguate. Other studies of both groundwater and surface water indicated similar results.

For this data evaluation, surface water and groundwater analyses were compared to US EPA Maximum Contaminant Levels (MCL) for drinking water (Tables 5-3) and National Secondary Drinking Water Standards (Table 5-4). MCLs are defined by Primary Drinking Water regulations pursuant to section 1412 of the Public Health Service Act, as amended by the Safe Drinking Water Act (Pub. L. 93-523); and related regulations applicable to public water systems. Secondary Drinking Water Standards outline levels of aesthetic drinking water quality relative to the public acceptance of drinking water. At very high concentrations of these contaminants, health implications, as well as aesthetic degradation, may also exist. These regulations are not federally enforceable but are intended as guidelines.

As mentioned earlier, concentrations of parameters which exceed either MCLs or NSWQS are highlighted in Appendix A with exceedances of secondary standards in light gray and MCL concentrations in light blue. Based on this review, the following parameters are of primary concern:

**Secondary Water Quality Standards**

- Total Dissolved Solids – nearly all samples both surface and groundwater exceed the Secondary Water Quality Standard of 500 mg/L
- Sulfate – most surface water and groundwater exceed the Secondary Water Quality Standard of 250 mg/L
- Manganese – several exceedances of the secondary standard of 0.05 mg/L during the 10 year monitoring period for both surface water and groundwater. These included (number of times exceeded are in parentheses): MW-2 (10), MW-3 (3), MW-6 (7), SPOP35 (6), NPOP20W (10), NPOP20E (10), RT (2), LRM (5), LRP (6), PM (7), AND URP (8).
- pH – Two samples were non-compliant, one from URM and the other from SPOP34.

**Primary Water Quality Standards (Maximum Contaminant Limits)**

- Fluoride – Concentrations exceeding 4 mg/L were found in all samples taken from MW-1, an upgradient well.
- Lead – One excursion of the standard of 0.015 mg/L of was found in MW-1

- Arsenic – One sample from MW-4 exceeded the standard of 0.01 mg/L.
- Gross Alpha – Several samples exceeded 15 pCi/L. These included (number of times exceeded are in parentheses): MW-1 (1), MW-2 (9), MW-3 (6), MW-4 (9), MW-5 (3), MW-6 (8), MW-7 (4), SPOP35 (9), SPOP34 (9), NPOP20W (9), NPOP20E (9). Of primary concern are samples taken from pit wells which ranged between 8,966 to over 67,000 pCi/L of NPOP20E, 280.7 to 707.71 pCi/L for NPOP20W, 1,022 to 54,000 pCi/L for SPOP35, and 55.59 to 1,430 pCi/L to SPOP35.
- Uranium – Like Gross Alpha, numerous samples exceeded the MCL of 0.03 mg/L. These included (number of times exceeded are in parentheses): MW-1 (1), MW-2 (9), MW-3 (8), MW-4 (9) MW-5 (3), MW-6 (9), MW-7 (4), RT (9), LRM (9), PM (8), URM (5), URP (5), Lake (2), NPOPO20W (9), NPOP20E (9), SPOP34(8), and SPOP35(9). The Paguate Reservoir is a public recreation area used for fishing.
- Radium 226 – Fewer samples exceeded the standard of 5 pCi/L. No surface water samples were above the standard. Groundwater wells exceeding the standard included (number of times exceeded are in parentheses): MW-1 (1), MW-6 (1), MW-7 (4), NPOP20W (1), NPOP20E (8), SPOPO34 (8) and SPOP35 (8).

Again, wells completed in fill were of most concern with samples from NPOP20E ranging between 23.5 and 65.69 pCi/L, SPOPO34 ranging between 5 and 62 pCi/L and SPOP35 ranging between 11 and 45 pCi/L.

**Table 5-4**
**National Maximum Contaminate Levels (USEPA, 2002)**

| Inorganic Chemicals Contaminant | MCL mg/L | Potential Health Effects from Ingestion of Water | Sources of Contaminant in Drinking Water |
|---|---|---|---|
| Arsenic | 0.010 as of 01/23/06 | Skin damage or problems with circulatory systems, and may have increased risk of getting cancer | Erosion of natural deposits; runoff from orchards, runoff from glass & electronics production wastes |
| Barium | 2 | Increase in blood pressure | Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits |
| Cadmium | 0.005 | Kidney damage | Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints |
| Chromium (total) | 0.1 | Allergic dermatitis | Discharge from steel and pulp mills; erosion of natural deposits |
| Copper | TT; Action Level=1.3 | Short term exposure: Gastrointestinal distress Long term exposure: Liver or kidney damage People with Wilson's Disease should consult their personal doctor if the amount of copper in their water exceeds the action level | Corrosion of household plumbing systems; erosion of natural deposits |
| Cyanide (as free cyanide) | 0.2 | Nerve damage or thyroid problems | Discharge from steel/metal factories; discharge from plastic and fertilizer factories |

| Inorganic Chemicals Contaminant | MCL mg/L | Potential Health Effects from Ingestion of Water | Sources of Contaminant in Drinking Water |
|---|---|---|---|
| Fluoride | 4.0 | Bone disease (pain and tenderness of the bones); Children may get mottled teeth | Water additive which promotes strong teeth; erosion of natural deposits; discharge from fertilizer and aluminum factories |
| Lead | 0.015 | Infants and children: Delays in physical or mental development; children could show slight deficits in attention span and learning abilities, Adults: Kidney problems; high blood pressure | Corrosion of household plumbing systems; erosion of natural deposits |
| Mercury (inorganic) | 0.002 | Kidney damage | Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and croplands |
| Nitrate (measured as Nitrogen) | 10 | Infants below the age of six months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome. | Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits |
| Nitrite (measured as Nitrogen) | 1 | Infants below the age of six months who drink water containing nitrite in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome. | Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits |
| Selenium | 0.05 | Hair/fingernail loss; circulatory problems | Erosion of natural deposits; discharge from mines |
| Alpha particles | 15 picocuries per Liter (pCi/L) | Increased risk of cancer | Erosion of natural deposits of certain minerals that are radioactive and may emit a form of radiation known as alpha radiation |
| Beta particles and photon emitters | 4 millirems per year | Increased risk of cancer | Decay of natural and man-made deposits of certain minerals that are radioactive and may emit forms of radiation known as photons and beta radiation |
| Radium 226 and Radium 228 (combined) | 5 pCi/L | Increased risk of cancer | Erosion of natural deposits |
| Uranium | 30 ug/L as of 12/08/03 | Increased risk of cancer, kidney toxicity | Erosion of natural deposits |

**Table 5-5**
**National Secondary Drinking Water Standards (USEP, 2002)**

| Contaminant | Secondary Standard |
|---|---|
| Aluminum | 0.05 to 0.2 mg/L |
| Chloride | 250 mg/L |
| Color | 15 (color units) |
| Copper | 1.0 mg/L |
| Corrosivity | noncorrosive |
| Fluoride | 2.0 mg/L |
| Foaming Agents | 0.5 mg/L |
| Iron | 0.3 mg/L |
| Manganese | 0.05 mg/L |
| Odor | 3 threshold odor number |
| pH | 6.5-8.5 |
| Silver | 0.10 mg/L |
| Sulfate | 250 mg/L |
| Total Dissolved Solids | 500 mg/L |
| Zinc | 5 mg/L |

### 5.3.2 Agriculture

Another concern of the ROD is the potential for the build up of salts in the bottom of the pit. Examination of the electric conductivity (EC) and TDS data indicates that all samples taken (in and out of pits) present a high to very high salinity hazard for irrigation water according to Table 5-5.

**Table 5-6**
**Salinity Hazard (USDA)**

| Salinity | Conductivity (□mhos/cm) | Dissolved solids (mg/L) |
|---|---|---|
| Low salinity, no detrimental effects expected | <250 | <200 |
| Medium salinity, detrimental effects to sensitive crops | 250 – 750 | 200 – 500 |
| High salinity, adverse effects on many crops | 750 – 2250 | 500 – 1500 |
| Very high salinity, suitable only for salt tolerant plants | 2250 – 5000 | 1500 – 3000 |

### 5.4 Quality Control and Quality Assurance

In the evaluation of water quality data, field and laboratory quality control and quality assurance measures are of primary concern. The Jackpile Project Environmental Monitoring Plan (Jacobs Engineering Group Inc.) goes into detail on how samples are to be collected in the field and how duplicate samples are to be used to ensure that the laboratory analyses are acceptable. For this review, it is assumed that these procedures were followed. Even though duplicate samples were taken, it is not apparent that these data were used anytime during the ten years of post reclamation monitoring to check on the accuracy of the lab. In addition, cation-anion balance calculations were not performed. These are good indicators of the validity of the laboratory data by equating the percentage of cations and anions in meq/L. The value should be within 5%. As a spot check of the data, cation-anion balances were performed for each of the samples. Table 5-6 presents the results of this review.

**Table 5-7**
**Post-reclamation Sample Evaluation - Cation-Anion Balances**

| Sampling Point | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|
| MW-1 | **12.8** | 3 | 1.9 | 3.6 | *7.9* | **10.8** | 4.9 | 3.7 | 1.8 |
| MW-2 | *6* | 1 | 0.2 | *6.9* | *8.2* | *7.8* | **10.1** | 1 | 1.3 |
| MW-3 | 1.4 | **18** | 1.4 | **13** | **13** | **12** | **30** | 2.1 | 3 |
| MW-4 | 1.2 | **17** | *10* | *6* | **11** | *8* | **35** | 0.3 | 2 |
| MW-5 | 0.8 | 0.8 | *7* | 4 | *8* | *10* | *7* | 2 | 3 |
| MW-6 | 1.2 | *1.3* | 1.2 | 0.4 | *6* | *6* | *3* | *8* | 1.3 |
| MW-7 | 4 | *7* | 3 | **12** | 0.67 | **11** | *10* | *6* | 1.3 |
| SW-RT | 1.8 | *6.9* | 0.5 | *9* | **14** | *5* | **19** | 3 | 0.02 |
| SW-LRM | *6* | 2.5 | *9.7* | **18** | **11** | *6.3* | **14.5** | 3.2 | *5.4* |
| SW-LRP | 1.5 | 2.3 | *6.2* | *7.6* | *9.1* | **36** | **13.6** | 1.7 | *5.4* |
| SW-PM | 0.5 | **10.2** | 2.6 | *5.1* | *7.4* | *6.9* | **11.3** | 3.8 | 2.1 |
| SW-URM | 1.9 | 0.2 | 1.3 | *5.9* | **10.2** | *6.7* | 1.2 | *5.5* | 0.9 |
| SW-URD | *8.2* | *8.2* | 2.3 | **12.5** | **12.9** | *8.9* | **15.9** | 4 | *6.1* |
| SW-LAKE | | | | | 2.2 | *9.3* | **18.1** | **12.4** | **14.6** |
| SPOPO-35 | **31.8** | **21.5** | **18.1** | 0.31 | 4.9 | 4.6 | 4.4 | *5.2* | **34** |
| SPOP-34 | 2 | *6.6* | 3.6 | *9.6* | *5.2* | *7.6* | *6.6* | 3.6 | **22** |
| NPOP20W | **61** | **13** | *6.1* | 1.2 | *8* | 4.3 | **14.9** | *5.6* | 3.8 |
| NPOP20E | **23** | **52** | **49** | 2 | 9.8 | *6.4* | 4.3 | 3.4 | 2.6 |

| | | |
|---|---|---|
| Unacceptable | **Bold** | > 10% cation-anion balance |
| Marginal | *Italics* | > 5% and <=10% cation-anion balance |
| Acceptable | Regular | < 5% cation-anion balance |

The results of this analysis indicate the following:

| | | |
|---|---|---|
| 25% | Unacceptable | > 10% cation-anion balance |
| 33% | Suspect | > 5% and <=10% cation-anion balance |
| 42% | Acceptable | < 5% cation-anion balance |

Having only 42% in the acceptable range is a point of concern for the accuracy of the analytical data.

## 6.0 CONCLUSIONS AND RECOMMENDATIONS

Based on this review, it is concluded that the intent of the ROD was met, but there are some rather large data gaps and conclusions cannot be drawn as to environmental impacts and long term health risks associated with the closed mine.

1 As presented in Table 5-1 and repeated below in Table 6-1, the condition of post-reclamation water quality data had both positives and negatives. Most importantly, it is apparent that over the last ten years no one appears to have taken responsibility for the data. Without a responsible party, it would be impossible to develop an understanding of the data and determine if any further corrective action would be required.

**Table 6-1**
**Evaluation of Post Reclamation Water Quality Data**

| Positives | Negatives |
|---|---|
| • Lab sheets were clear.<br>• Analytical methods were explained.<br>• Duplicate samples and QA/QC samples were identified<br>• Detection limits were for the most part satisfactory<br>• With a few exceptions, all parameters were analyzed each year, as suggested by the Environmental Monitoring program<br>• Samples were collected consisting during the months of April and May for each year | • Data was disorganized.<br>• The lack of standard QA/QC being performed on the laboratory results, resulted in suspect data.<br>• Data transfer to logical tables as presented in Appendix A was sometimes difficult and time consuming.<br>• It appears that no effort was made by the Reclamation project to review the data on an annual basis to evaluate trends and concerns.<br>• No water quality standards were defined in the ROD, Monitoring Plan or EIS.<br>• No wells were installed in the Jackpile Pit.<br>• Ponded water in open pits was not sampled.<br>• No well in the Jackpile Sandstone formation near the downgradient boundary.<br>• Water table elevation data were incomplete.<br>• Flow, although not required by the ROD would be helpful in understanding the surface water flow system. |

The four data gaps 1) the depth to water measurements were reportedly recorded, but the record of those depths was incomplete, 2) the Jackpile pit wells were not installed until

2007, 3) the ponded water was not sampled and analyzed until 2007, and 4) a downgradient boundary well in the Jackpile Sandstone was not installed (the Jackpile Sandstone is reportedly not present at the boundary), collectively represent a major deviation from the ROD and is therefore, ***non-compliant.***

2. Several analytes exceeded primary and secondary drinking water standards at most sampling stations. Parameters of concern included:

   **Secondary Standards**

   - Total Dissolved Solids – nearly all samples, both surface and groundwater, exceed the secondary of 500 mg/L
   - Sulfate – like TDS – most surface water and groundwater exceed the secondary standard of 250 mg/L
   - Manganese – several exceedances of the secondary standard of 0.05 mg/L during the 10 year monitoring period for both surface water and groundwater. These included (no. of excursions are in parentheses): MW-2 (10), MW-3 (3), MW-6 (7), SPOP35 (6), NPOP20W (10), NPOP20E (10), RT (2), LRM (5), LRP (6), PM (7), AND URP (8).
   - pH – Two samples were in non-compliance, one from URM and the other from SPOP34.

   **Primary Standards (MCLs)**

   - Fluoride – Concentrations exceeding 4 mg/L were found in all samples taken from MW-1
   - Lead – One excursion of the standard of 0.015 mg/L was found in MW-1
   - Arsenic – One sample from MW-4 exceeded the standard of 0.01 mg/L.
   - Gross Alpha – Several samples exceeded 15 pCi/L. These included (no. of excursions are in parentheses): MW-1 (1), MW-2 (9), MW-3 (6), MW-4 (9), MW-5 (3), MW-6 (8), MW-7 (4), SPOP35 (9), SPOP34 (9), NPOP20W (9), NPOP20E (9).

     Of primary concern are samples taken from pit wells which ranged between 8,966 to over 67,000 pCi/L of NPOP20E, 280.7 to 707.71 pCi/L for NPOP20W, 1,022 to 54,000 pCi/L for SPOP35, and 55.59 to 1,430 pCi/L to SPOP35.
   - Uranium – Like Gross Alpha, numerous samples exceeded the MCL of 0.03 mg/L. These included (no. of excursions are in parentheses): MW-1 (1), MW-2 (9), MW-3 (8), MW-4 (9) MW-5 (3), MW-6 (9), MW-7 (4), RT (9), LRM (9), PM (8), URM (5), URP (5), Lake (2), NPOPO20W (9), NPOP20E (9), SPOP34(8), and SPOP35(9).
   - Radium 226 – Fewer samples exceeded the standard of 5 pCi/L. No surface water samples were above the standard. Groundwater wells exceeding the standard included (no. of excursions are in parentheses): MW-1 (1), MW-6 (1), MW-7 (4), NPOP20W (1), NPOP20E (8),

SPOPO34 (8) and SPOP35 (8). Again, wells completed in fill were of most concern with samples from NPOP20E ranging between 23.5 too 65.69 pCi/L, SPOPO34 ranging between 5 and 62 pCi/L and SPOP35 ranging between 11 and 45 pCi/L.

**Agricultural**

- Based on the salinity results alone, the groundwater appears to be unsuitable for irrigation and stock watering.
- Only 42% of the analyses had cation-anion balances within acceptable range. This leads to a concern on the accuracy of the laboratory.

Based on these observations, the following recommendations can be made:

1. Install and sample Jackpile pit wells.
2. Install a well in the Jackpile Sandstone formation near the boundary (near MW-6)
3. Sample ponded water within the pits.
4. Monitoring should continue for a least one more year. Parameters which should be monitored include field parameters, major cations and anions, manganese, total dissolved solids, arsenic, fluoride, lead, gross alpha, radium 226, and uranium (total).
5. With the completion of sampling, the accuracy of the data should be evaluated. The laboratory should be required to perform cation-anion balances and if not within an acceptable range the samples should be redone.
6. A risk assessment should be performed to determine the potential hazards and risks of the high levels of gross alpha, radium 226, and uranium in most samples, especially in the wells in fill material.
7. The compliance boundary needs to be defined.
8. With both surface water and groundwater samples showing some level of contamination, an evaluation should be made to determine if any contaminants have migrated beyond the compliance boundary.

## 7. REFERENCES

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# APPENDIX A

## MONITORING DATAEVALUATION TABLES
## 1996-2007
## (On CD-ROM)

**Jackpile-Paguate Uranium Mine Record of Decision Compliance Assessment**

**CD-ROM**

**September 2007**

**Appendix D**

**Water Quality, WQ Addendum & Monitoring Results Tables**

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# APPENDIX B

# ANALYTICAL METHODS

## ANALYTICAL METHODS

| ANALYTE | TEST |
|---|---|
| Total Dissolved Solids | EPA 160.1 |
| Fluoride | EPA 300.0 |
| pH | EPA 150.1 |
| Alkalinity, Total | EPA 310.1 |
| Alkalinity, Bicarbonate | EPA 310.1 |
| Alkalinity, Carbonate | EPA 310.1 |
| Sulfate | EPA 300.0 |
| Chloride | EPA 300.0 |
| Orthophosphate, as P | EPA 300.0 |
| Nitrate, as N | EPA 300.0 |
| Nitrite, as N | EPA 300.0 |
| Conductivity | EPA 120.1 |
| Cyanide, Total | EPA 335.2 / SM 4500 CN-C |
| Selenium, dissolved | EPA 200.8 ICP-MS |
| Molybdenum, dissolved | EPA 200.8 ICP-MS |
| Zinc, dissolved | EPA 200.8 ICP-MS |
| Magnesium, dissolved | EPA 200.8 ICP-MS |
| Calcium, dissolved | EPA 200.8 ICP-MS |
| Barium, dissolved | EPA 200.8 ICP-MS |
| Lead, dissolved | EPA 200.8 ICP-MS |
| Manganese, dissolved | EPA 200.8 ICP-MS |
| Potassium, dissolved | EPA 200.8 ICP-MS |
| Chromium, dissolved | EPA 200.8 ICP-MS |
| Cadmium, dissolved | EPA 200.8 ICP-MS |
| Arsenic, dissolved | EPA 200.8 ICP-MS |
| Vanadium, dissolved | EPA 200.8 ICP-MS |
| Sodium, dissolved | EPA 200.8 ICP-MS |
| Silver, dissolved | EPA 200.8 ICP-MS |
| Silica, as SiO2 | EPA 200.8 ICP-MS |
| Mercury | EPA 245.1 CVAA |
| Gross Alpha | EPA 900 |
| Gross Beta | EPA 900 |
| Radium-226 | 903.1 |
| Polonium-210 | ASL 300 Po-01 |
| Total Uranium | 908 |
| Lead-210 | ICHROM |

# JACKPILE-PAGUATE URANIUM MINE
# POST-RECLAMATION
# WATER QUALITY DATA REVIEW
# ADDENDUM

# Table of Contents

## 1.0 INTRODUCTION

This addendum addresses the water quality data received by OAS after the OAS Water Quality Data Review that was completed in the Fall of 2006. This addendum supplements the OAS report *"Jackpile-Paguate Uranium Mine Post-Reclamation Water Quality Review"*.

## 2.0 SAMPLING POINTS

- Initially, no wells were installed in the Jackpile Pit. This oversight was corrected in 2007 when two wells were placed in the Jackpile-Paguate pit fill material.

- The ponded water in the open pits was sampled for the first time in April 2007, when the pond in the North Paguate Pit was sampled and analyzed.

- Additional rounds of sampling were also conducted in 2006 and 2007 at the historic surface and ground water sampling points.

## 3.0 QUALITY CONTROL AND QUALITY ASSURANCE

The same conclusions regarding QA/QC that were presented in the Water Quality report still hold. Namely; there are many qualifiers (approaching 40%) in the reported laboratory data reports, the cations and anions are often out of balance, and there needs to be a thorough quality review of the reports and the laboratory QC.

## 4.0 CONTAMINANTS

The last two sequences of monitoring indicate the Total Dissolved Solids trends no longer hold. Several wells that had downward trends are now trending higher in TDS. The comparison of data to the Primary and Secondary Drinking Water Standards is updated to include the reporting years 1996 through 2007:

### 4.1 <u>Primary Drinking Water Regulations</u> (Maximum Contaminant Levels)

- Fluoride – Concentrations exceeding 4 mg/L were found in all samples taken from MW-1, an upgradient well\
- Lead – One excursion of the standard of 0.015 mg/L was found in MW-1
- Arsenic – One sample from MW-4 exceeded the standard of 0.01 mg/L.
- Gross Alpha – All surface waters, groundwaters, and pit wells had exceedances of the Gross Alpha MCL except for the reservoir. Many had exceedances for each sampling period.

**Table 4-1**
**Gross Alpha Exceedances of the 15 pCi/L MCL**

| Location | # samples > 15 pCi/L | Range | |
|---|---|---|---|
| **Groundwater** | | | |
| MW-1 | 1 of 9 | ND | 17.33 |
| MW-2 | 10 of 10 | 12.51 | 97.67 |
| MW-3 | 6 of 9 | 31.92 | 104.85 |
| MW-4 | 9 of 9 | 20.99 | 202.3 |
| MW-5 | 3 of 9 | ND | 23.94 |
| MW-6 | 9 of 9 | ND | 118.72 |
| MW-7 | 4 of 9 | 9.11 | 40.63 |
| **Surface Water** | | | |
| NP Pond | 1 of 1 | 1468.05 | |
| Railroad Tresel | 10 of 10 | 37.59 | 214.33 |
| Lower Rio M | 7 of 10 | 16.62 | 53.05 |
| Lower Rio P | 6 of 10 | 2.24 | 106.22 |
| P-M Confluence | 8 of 10 | 11.19 | 94.03 |
| Upper Rio M | 2 of 10 | ND | 35.11 |
| Upper Rio P | 1 of 10 | ND | 25.53 |
| Paguate Lake/Reservoir | 0 of 6 | ND | 3.04 |
| **Pit Wells** | | | |
| NP-OP- 20 W | 10 of 10 | 159.25 | 707.71 |
| NP-OP- 20 E | 10 of 10 | 8965.97 | 67,278.82 |
| JP-OP- 41 N | 1 of 1 | 385.07 | |
| JP-OP- 41 S | 1 of 1 | 323,803.05 | |
| SP-OP-34 | 10 of 10 | 74.09 | 1490.91 |
| SP-OP-35 | 10 of 10 | 1022 | 7385.57 |

- Uranium – All Surface waters, groundwaters, and pit wells had exceedances of the total uranium. Many had exceedances for each sampling period. The Lake/Reservoir is a public recreation area used for fishing.

**Table 4-2**
**Total Uranium Exceedances of the 0.03 mg/L MCL**

| Location | # samples > 0.03 mg/L | Range | |
|---|---|---|---|
| **Groundwater** | | | |
| MW-1 | 6 of 9 | 3.87 | 6.27 |

# APPENDIX E

## AERIAL PHOTOGRAPHS
## JACKPILE-PAGUATE URANIUM MINE
## 1989 – 2003
## (on DVD-ROM)

# Jackpile-Paguate Uranium Mine Record of Decision Compliance Assessment

**DVD-ROM**

**September 2007**

**Appendix E**

**Aerial Photographs 1989 - 2003**

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